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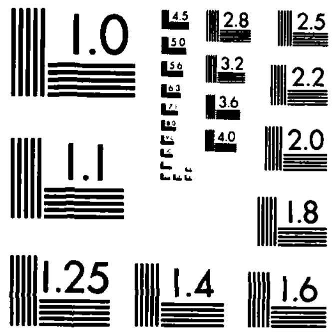

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NAVAL POSTGRADUATE SCHOOL

Monterey, California

THESIS

INTRODUCTION TO THE MICROCOMPUTERS FOR
SOLVING RADAR ELECTRONIC WARFARE PROBLEMS
AND

by

Constantinos D. Vergos

December 1985

Thesis Advisor: Harold A. Titus

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This thesis has been written to solve different types of problems through microcomputers in the radar and electronic warfare field. These problems are offered as subjects at the Naval Postgraduate School in Courses EC 4432/33, EC 4484, and EC 3431.

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so that anyone can change any given parameter or characteristics of radars and jammers and thus study their performance for the purpose of using or designing them.

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Introduction to the Microcomputers for Solving Radar and Electronic Warfare Problems

by

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Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN ELECTRICAL ENGINEERING

from the

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This thesis has been written to solve different types of problems through microcomputers in the radar and electronic warfare field. These problems are offered as subjects at the Naval Postgraduate School in Courses EC 4432/33, EC 4484, and EC 3431.

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I. INTRODUCTION

The intent of this thesis is to solve diverse types of problems in the field of radar and Electronic Warfare, with the help of microcomputers, in order to help training officers to better understand this area of technology.

Many of our Naval Officers today have microcomputers which they take to sea with them. In addition a new MIL-SPEC Hewlett-Packard microcomputer is becoming operational on all Naval combatants. These PC's have the potential for providing an excellent resource in the tactical training of the officer in problems in electronic warfare and radar. All too often at sea these technical problems are brushed aside and left for civilian technicians. There is however a great need for the technically trained officer to be able to handle the changing technical EW radar situations. These sample problems may provide help in attacking some of the problems that the operating Naval officer will encounter.

Microsoft Basic and the interactive method have been used to write the programs that solve these problems. Microsoft Basic is an easy language for anyone to understand and as a result, the user can easily modify the programs. Also, because Microsoft Basic is available in every microcomputer, there is no need for one to make changes to run these programs on different microcomputers. The interactive method gives one the opportunity to input any chosen data and the ability, by

changing this data, to study the different performances of radar and jammers.

In solving these problems, the following have been taken into account: The performance of the radars, the ability of the radars to track targets, the design of radars for special purposes, and the design and study of different types of jammers. Special emphasis has been given to select these problems so that there would be a diverse field of different types of radars and jammers for numerous purposes, including their use in different conditions of operations. This selection of problems has been done in such a way that they can help a training officer to comprehend and perceive or to help an engineer evaluate a radar or a jammer he/she may wish to design.

In Chapter II, the author presents material which is needed to solve the problems of Chapters III and IV. A brief explanation for each equation is given as in Skolnik [Ref. 1].

The third part of this thesis encompasses problems that refer entirely to radars.

The fourth part deals with the problems of radars and jammers and how dissimilar types of jammers affect the radars, problems in which different categories of transmitting and receiving antennas are examined, and problems on different types of jamming techniques. Most of these problems have been taken from [Ref. 3].

The conclusion drawn from this software development is contained in Chapter V, Conclusion.

Appendix A lists the computer programs and outputs from the results of each radar problem of Chapter II.

The contents of Appendix B are similar to Appendix A but deal with electronic warfare problems.

II. EQUATIONS AND FIGURES

The problems addressed here cover a wide range of questions that one might encounter in radar and EW. For example, what detection probability is required? What is the maximum range given a radar's power and target RCS? What range inaccuracies are involved when FM ranging and what problems in doppler radar occur in terms of blind spots? What improvements are gained from MTI radar in a clutter environment? How can the radar receiver power be computed, as well as the noise power, and signal-to-noise ratios? What are critical parameters in an MTI-chaff discriminator? In a phased array system, what is the beamwidth and phase shift between elements? These and many other problems are addressed.

Herein are the functional relationships in the field of radar and electronic warfare which are used to solve the problems in Chapters III and Iv. They are given with a brief description in [Refs. 1,2,3].

Maximum Unambiguous Range:

$$R_{unamb} = \frac{C}{2f_p} \qquad (1)$$

where:

f_p = pulse repetition frequency, Hz;

C = speed of light = 3×10^8 m/s.

The factor 2 appears in the denominator because of the two-way propagation of radar.

<u>Maximum radar range</u> in terms of radar and target parameters:

$$R_{max} = \left[\frac{P_t \; G \; A_e \; \sigma}{(4\pi)^2 \; S_{min}}\right] \tag{2}$$

where:

P_t = transmitted power, watts;

G = antenna gain;

A_e = antenna effective aperture, m^2;

= radar cross section, m^2;

S_{min} = minimum detectable signal, watts.

The radar equation (2) with some modifications becomes:

$$R^4_{max} = \frac{P_{av} \; G \; A \; \rho_a \; \sigma \; n \; E_i(n)}{(4\pi)^2 \; k \; T_o \; F_n \; (B_\tau) \; f_p \; (S/N)_1 \; L_s} \tag{2a}$$

where:

R_{max} = maximum radar range, m;

G = antenna gain;

A = antenna aperture, m^2

ρ_a = antenna efficiency;

n = number of hits integrated

$E_i(n)$ = integration efficiency (less than unity)

L_s = system losses (greater than unity) not included in other parameters;

σ = radar cross section of target, m^2

F_n = noise figure;

k = Boltzmann's constant = 1.38×10^{-23} J/deg.

T_o = standard temperature = 290°k

B = receiver bandwidth, Hz;

τ = pulse width, s;

f_p = pulse repetition frequency, Hz

$(S/N)_1$ = signal-to-noise ratio required at receiver output (based on single-hit detection).

Equation 2(a) is written in terms of power; it can also be written in terms of energy with the following modifications:

(a) The energy in the transmitted pulse is

$$E_\tau = P_{av}/f_p = P_t \tau \; .$$

(b) The signal-to-noise power ratio $(S/N)_1$ can be replaced by the signal-to-noise energy ratio $(E/N_o)_1$, where $E = s/\tau$ (received signal energy), and $N_o = N/B$ (noise energy).

(c) $B\tau \cong 1$, and $T_oF_n = T_s$ = system noise temerature.

Then, the radar equation 2(a) can be written as:

$$R^4_{max} = \frac{E_\tau \, GA \, \rho_a \, \sigma \, n E_i(n)}{(4\pi)^2 \, kT_s \,)E/N_o)_1 L_s} \tag{2b}$$

Equation 2(b) is applied to rectangular pulses, and if matched filter detection is employed, can be applied to other waveforms as well.

Thermal-noise power, generated by a receiver is:

$$N_n = k\,T\,B_n \tag{3}$$

where:

B_n = receiver's bandwidth, Hz;

T_s = temperature at which the noise power is generated, degrees kelvin;

k = Boltzmann's constant = 1.38×10^{-23} J/deg.

Minimum detectable signal S_{min}:

$$S_{min} = k\,T_o\,B_n\,F_n\,(S_o/N_o)_{min} \tag{4}$$

where:

k = Boltzmann's constant = 1.38×10^{-23} J/deg.;

T_o = standard temperature = 290 degrees kelvin;

B_n = receiver's bandwidth, Hz;

F_n = receiver's noise figure;

$(S_o/N_o)_{min}$ = minimum ratio of output (IF) signal-to-noise ratio, required for detection.

False alarm probability: Pf_a,

$$Pf_a = \frac{1}{T_{fa} \times B_{IF}} \tag{5}$$

$$T_{fa} = \frac{1}{B_{IF}} \exp \frac{V_T^2}{2\psi_o} \tag{5a}$$

where:

T_{fa} = false alarm time;

B_{IF} = bandwidth of the IF amplifier;

V_T = threshold voltage

ψ_o = noise voltage.

Number of pulses n_B, returned from a point target, as the radar antenna scans through its beamwidth is:

$$n_B = \frac{\theta_B f_p}{\dot{\theta}_s} = \frac{\theta_B f_p}{\sigma w_m} \tag{6}$$

where:

θ_B = antenna beamwidth, deg.;

f_p = pulse repetition frequency, Hz;

$\dot{\theta}_s$ = antenna scanning rate, deg/s;

w_m = antenna scan rule, rpm.

Integration efficiency $E_i(n)$,

$$E_i(n) = \frac{(S/N)_1}{n(S/N)_n} \tag{7}$$

where:

$(S/N)_1$ = signal-to-noise ratio of a single pulse required to produce given probability of detection (for n = 1);

$(S/N)_n$ = signal-to-noise ratio per pulse required to produce some probability of detection when n pulses are integrated at the same P_d and P_{FA};

n = number of pulses integrated.

False alarm number, n_f:

$$n_f = \frac{1}{P_{fa}} \tag{8}$$

where:

P_{fa} = false alarm probability.

Collapsing loss, $L_i(m,n)$:

$$L_i(m,n) = \frac{L_i(m+n)}{L_i(n)} \tag{9}$$

where:

$L_i(m+n)$ = integration loss for (m+n) pulses;

$L_i(n)$ = integration loss for n pulses;

n = noise pulses;

m = signal-plus-noise pulses.

Doppler frequency shift, f_d:

$$f_d = \frac{2u_r}{\lambda} = \frac{2\,u_r f_o}{c} \tag{10}$$

where:

u_r = relative (or radial) velocity of target with respect to radar;

f_o = transmitted frequency;

c = velocity of propagation = 3×10^8 w/s

If f_d is in Hz, u_r in knots, and λ in meters, then

$$f_d = \frac{1.03u_r}{\lambda} \tag{10a}$$

Beat frequency, f_r:

$$f_r = \dot{f}_o T = \frac{2R}{c}\dot{f}_o \tag{11}$$

where:

$\dot{f}_o$ = rate of change of the corner frequency.

Blind speeds, u_n:

$$u_n = \frac{n\lambda}{2T_p} = \frac{n\lambda f_p}{2} \qquad n = 1,2,3,... \tag{12}$$

where:

f_p = pulse repetition frequency, Hz;

λ = wavelength of radiated frequency, w.

If λ is measured in meters, f_p in Hz, and the relative velocity in knots, the blind speeds are:

$$u_n = \frac{n\,\lambda\,f_p}{1.02} \doteq n\,\lambda\,f_p \tag{12a}$$

Clutter attenuation, CA:

$$CA = \frac{0.5}{1 - \exp(-2\pi^2\,T^2\,\sigma_c^2\,)} \tag{13}$$

where:

π = 3.14159;

T = time delay of the delay line;

σ_c = rms frequency clutter spread.

If the exponent in the denominator of Eq. (13) is small, then

$$CA = \frac{a\,f_p^2}{2\pi^2\,f_o^2} \tag{13a}$$

where:

a = parameter dependent upon clutter = $c^2/8\sigma_u^2$;

σ_u = rms velocity spread;

f_p = pulse repetition frequency;

f_o = radar carrier frequency.

Improvement factor of 2 pulse canceller,

$$I_{1c} = \frac{a\, f_p^2}{\pi^2\, f_o^2} \tag{14}$$

Improvement factor for a double delay line canceller

$$I_{2c} = \frac{a^2\, f_p^4}{2\pi^4\, f_o^4} \tag{15}$$

Power antenna gain,

$$G = P_r\, G_D \tag{16}$$

where:

P_r = radiation efficiency factor;

G_D = directive gain of the antenna.

The gain G, and the effective area Ae of a lossler antenna are related by

$$G = \frac{4\,\pi\, Ae}{\lambda^2} = \frac{4\,\pi\, p_o\, A}{\lambda^2} \tag{16a}$$

$$Ae = p_a A$$

where:

λ = wavelength of radiated energy, m;

A = physical area of antenna;

p_a = antenna aperture efficiency.

Also, the relationship between the gain and the beamwidth of an antenna is given by

$$G \doteq \frac{20,000}{\theta_B \phi_B} \tag{16b}$$

where θ_B, ϕ_B are half power beamwidths, in degrees, measured in the two principal planes.

Array antenna radiation pattern,

$$G(\theta) = G_c(\theta) G_a(\theta) \tag{17}$$

where:

$G_c(\theta)$ = element factor;

$G_a(\theta)$ = array factor.

Half power beamwidth,

$$\theta_B = \frac{0.886\ \lambda}{N_d \cos\ \theta_o} \tag{18}$$

where:

λ = wavelength, m;

N = number of error elements;

d = distance that the array elements are spaced, m;

θ_o = beam position off broadside.

Phase shift between adjacent elements of the array,

$$\phi = 2\pi(d/\lambda)\sin\theta_o \tag{19}$$

where d, λ, θ_o are defined as in Eq. (18).

Distance between radar and target along the line of sight,

$$d_o = \sqrt{2kah_1} + \sqrt{2kah_2} \tag{20}$$

where:

a = earth's radius;

k = factor account for refraction due to a uniform gradient of refraction,;

h_1, h_2 = heights of radar antenna and target, respectively.

Power received from the clutter,

$$c = \frac{P_t G A_e \sigma_c}{(4\pi)^2 R^4} \tag{21}$$

where:

P_t = transmitter power;

G = antenna gain;

A_e = antenna effective aperture;

R = range

σ_c = clutter cross section.

Signal power returned from a target with cross section σ_t,

$$S = \frac{P_t G A_e \sigma_t}{(4\pi)^2 R^4} \tag{22}$$

Range of a 0th radar,

$$R^4 = \frac{P_{av} G_t G_r \lambda^2 \sigma F_p^2 T_c}{(4\pi)^3 N_u (S/N) L_s} \tag{23}$$

where:

R	=	range;
P_{av}	=	average power;
G_t	=	transmitting antenna gain;
G_r	=	receiving antenna gain;
λ	=	wavelength;
σ	=	target cross section;
F_p	=	factor to account for the one-way propagation effects;
T_c	=	coherent processing gain;
N_o	=	receiver noise power per unit bandwidth;
(S/N)	=	signal-to-noise (power) ratio;
L_s	=	system losses.

Cross over range,

$$R_{ss}^2 = \frac{P_{tr}}{P_{ts}} \frac{G_r}{G_j} \frac{\sigma}{4\pi} \frac{B_j}{B_r} \frac{J}{S} \tag{24}$$

where:

P_{tr} = radar transmitter power;

P_{tj} = jammer transmitter power;

G_r = radar antenna gain;

G_j = jammer antenna gain;

σ = target cross section;

B_j = jammer bandwidth;

B_r = radar signal bandwidth;

J/S = jammer-to-radar signal (power) ratio at the output of the IF required to mask the radar signal.

<u>Jammer noise power</u> per hertz at the radar,

$$N_{oJ} = \frac{P_{tj}\, G_j\, A_e}{4\,\pi R^2\, B_j} \qquad (25)$$

where:

A_e = effective receiving aperture of the radar antenna;

R = range of jammer from radar;

G_j = jammer antenna gain;

B_j = jammer bandwidth;

P_{tj} = jammer transmitter power.

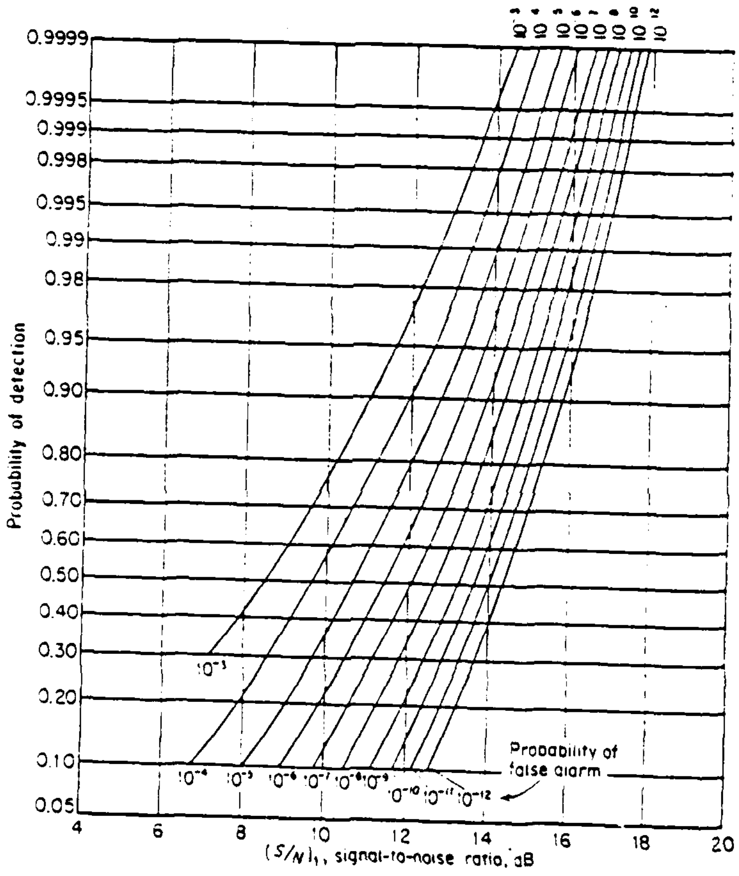


Figure 2.1. Probability of detection for a sine wave in noise as a function of the signal-to-noise (power) ratio and the probability of false alarm

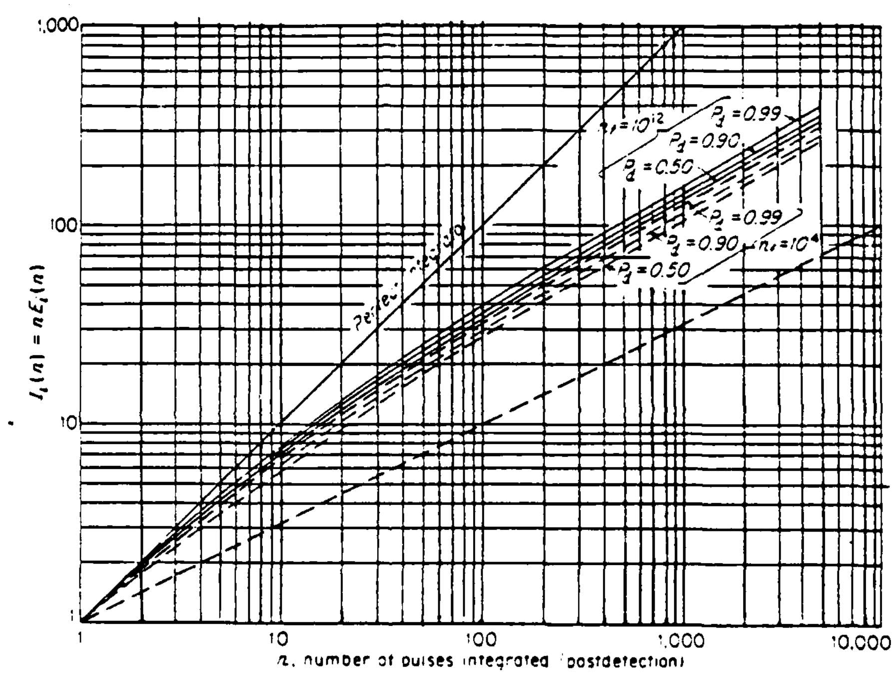


Figure 2.2. Integration-improvement factor, square law detector, P_d = probability of detection, $n_f = T_{fa}$ = false alarm number, T_{fa} = average time between false alarms, B = bandwidth

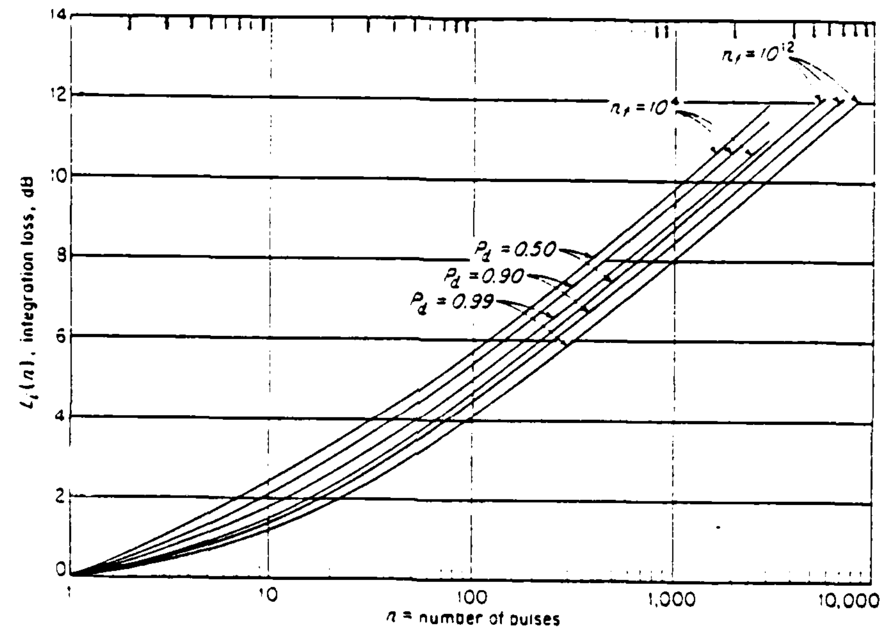


Figure 2.3. Integration loss as a function of n, the number of pulses integrated P_d, and n_f

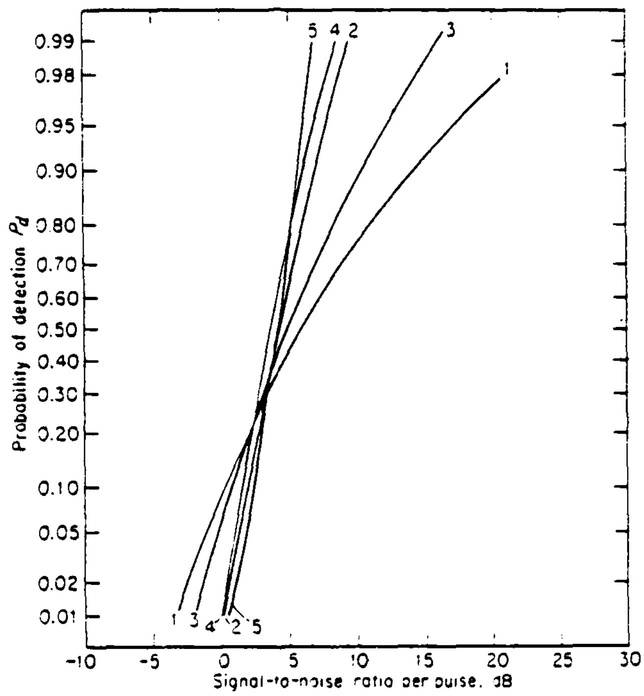


Figure 2.4. Comparison of detection probabilities for five different models of target fluctuation for n = 10 pulses integrated and false-alarm number $n_f = 10^8$

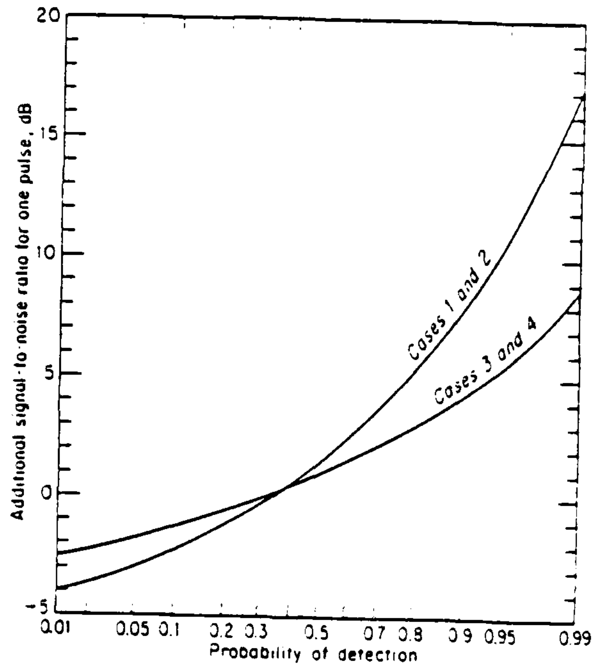


Figure 2.5. Additional signal-to-noise ratio required to achieve a particular probability of detection, when the target cross section fluctuates, as compared with a non fluctuating target; single hit, n = 1. (To be used in conjunction with Fig. 2.1 to find $(S/N)_1$)

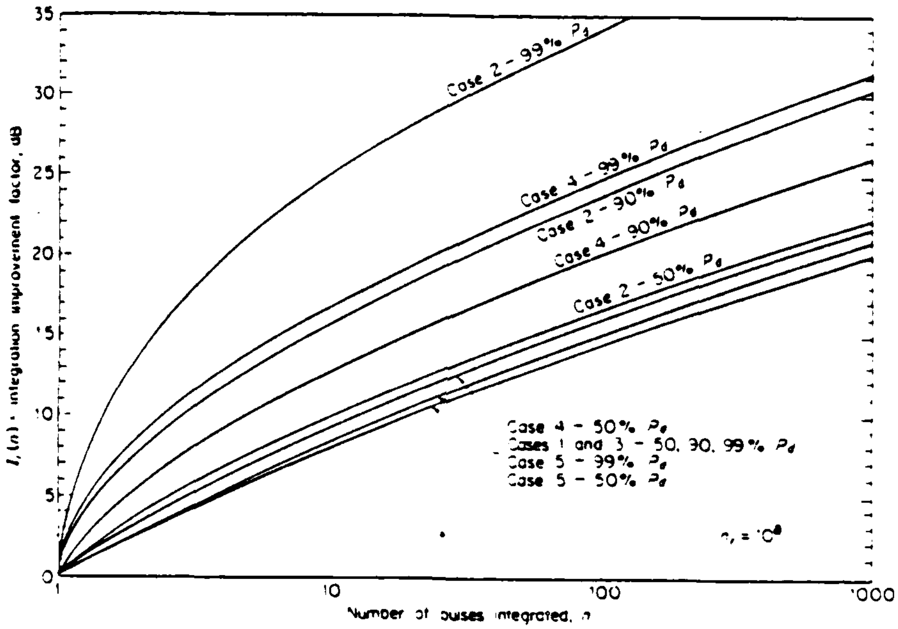


Figure 2.6. Integration-improvement factor as a function of the number of pulse integrated for the five types of target fluctuation considered

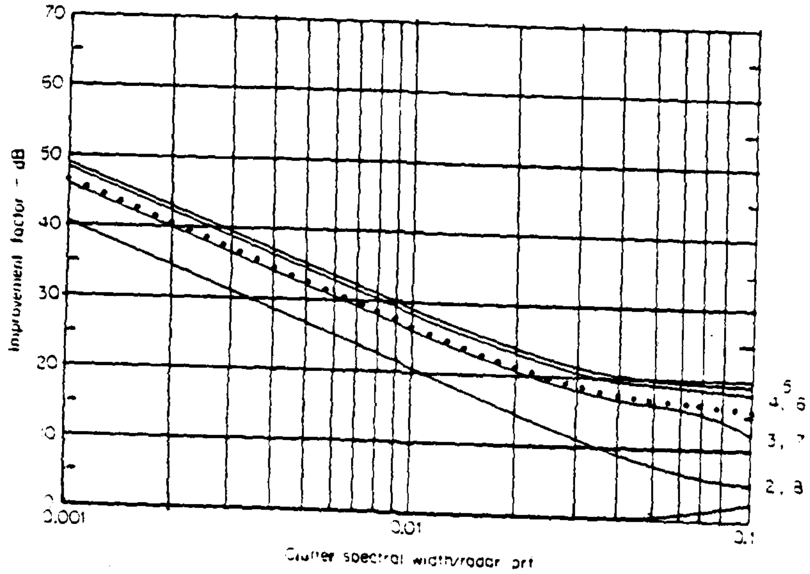


Figure 2.7. Improvement factor for each filter of an 8-pulse doppler filter bank with uniform weighting as a function of the clutter spectral width (standard deviation). The average improvement factor for all filters is indicated by the dotted curve

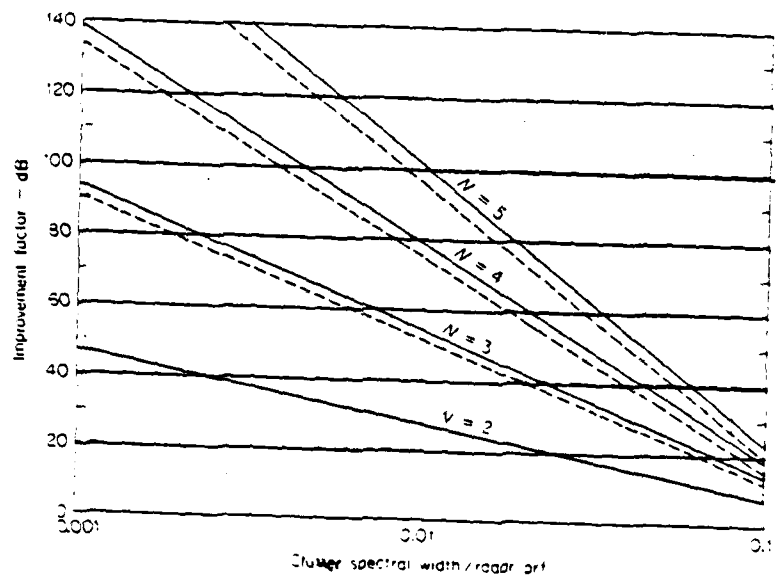


Figure 2.8. Improvement factor for a N-pulse canceler with optimum weights (solid curves) and binomial weights (dashed curves), as a function of the clutter spectral width

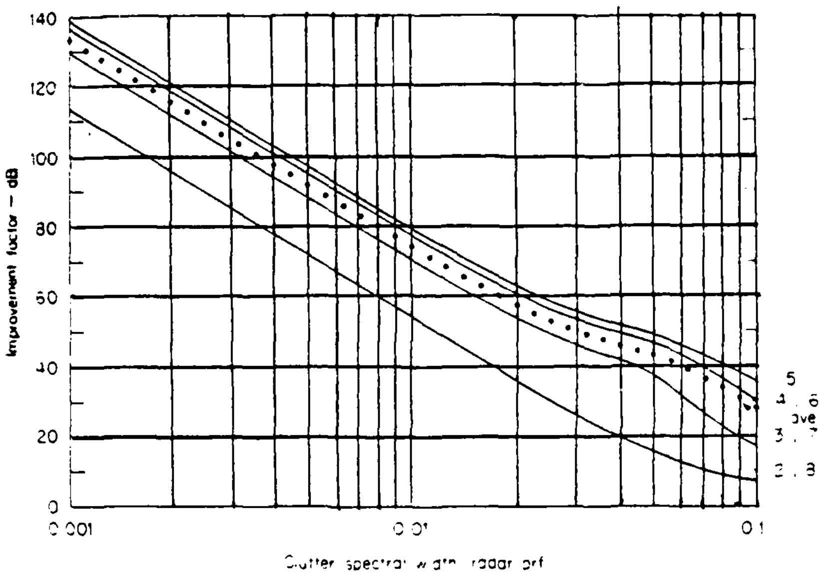


Figure 2.9. Improvement factor for a three-pulse (double canceler) MTI cascaded with an 8-pulse filter bank, or integrator, with uniform amplitude weights. The improvement for all filters is indicated by the dotted curve.

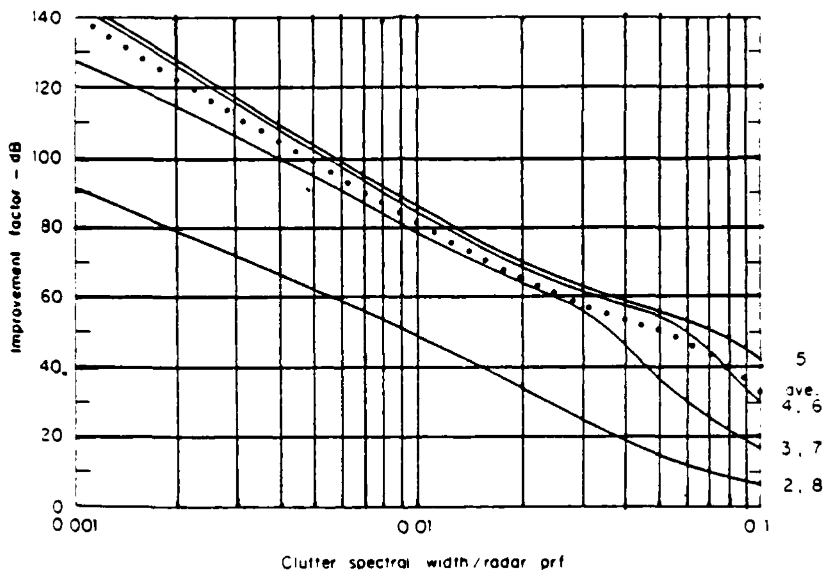


Figure 2.10. Improvement factor for a three-pulse (double canceler) MTI cascaded with an 8-pulse filter bank, or integrator, with 25-db Chebyshev weights. The improvement for all filters is indicated by the dotted curve

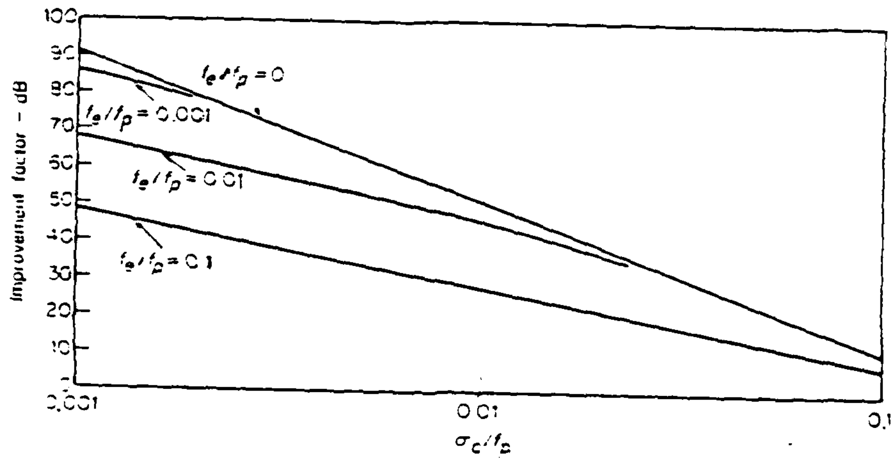


Figure 2.11. Effect of a nonzero clutter doppler frequency on the improvement factor of a three pulse canceler. f_θ = mean frequency of the clutter spectrum, f_p = pulse repetition frequency

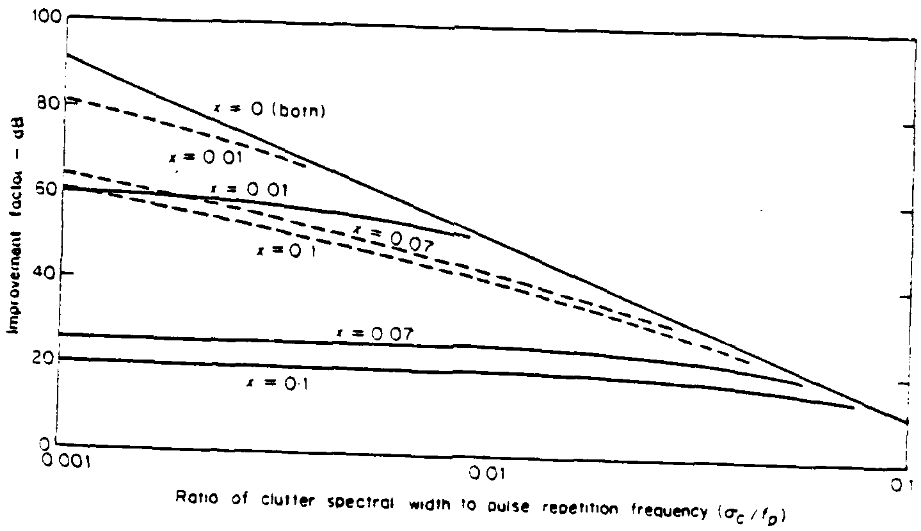


Figure 2.12. Improvement factor of a three-pulse canceler limited by platform motion (solid lines). Effect of the DPCA compensation (dashed lines). x is the fraction of the antenna aperture that the antenna is displaced per interpulse period. (x = 0 corresponds to no platform motion)

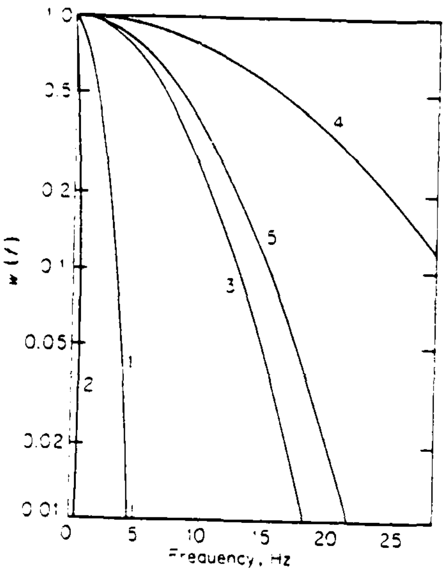


Figure 2.13. Power spectra of various clutter targets (1) Heavily wooded hills, 20 mi/h wind blowing ($a = 2.3 \times 10^{17}$); (2) sparsely wooded hills, calm day ($a = 3.9 \times 10^{19}$); (3) sea echo, windy day ($a = 1.41 \times 10^{16}$); (4) rain clouds ($a = 2.8 \times 10^{15}$); (5) chaff ($a = 1 \times 10^{16}$)

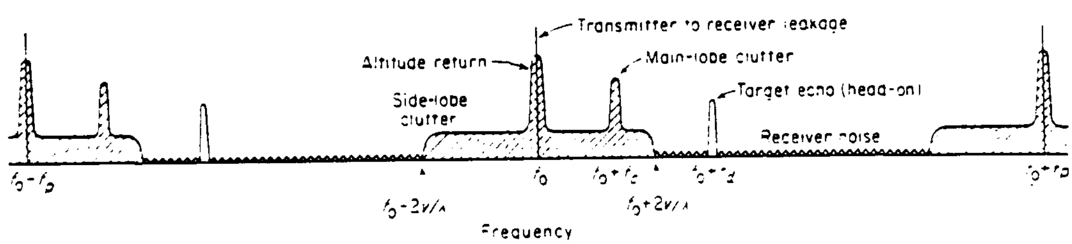


Figure 2.14. Portion of the received signal spectrum of the RF carrier frequency f_o, for a pulse-doppler AMTI radar

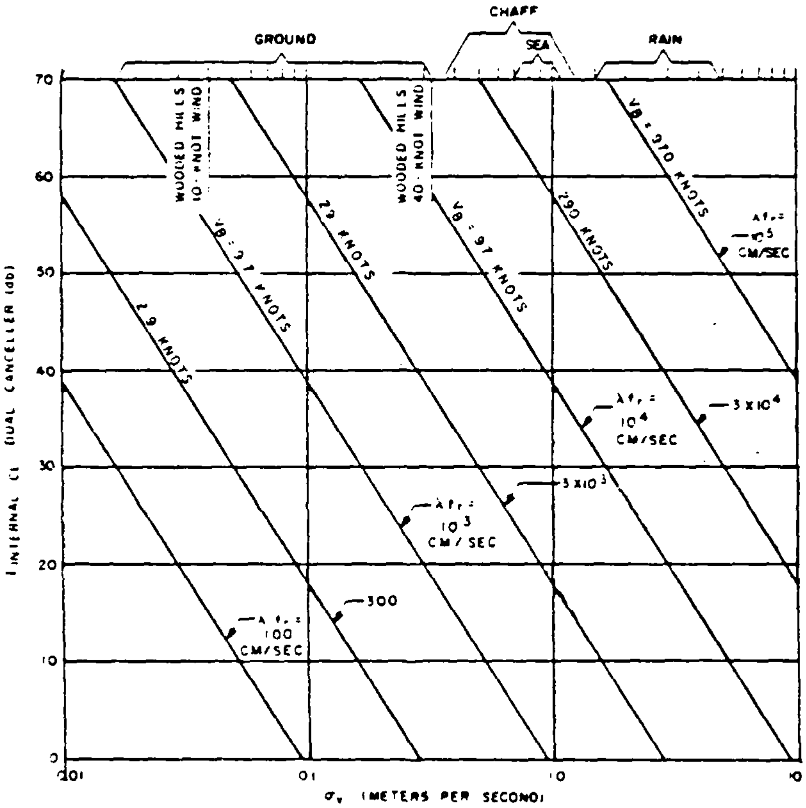


Figure 2.15. MTI improvement factor as a function of the RMS velocity spread of clutter for a two-delay canceler (no feedback)

Comparison of several types of spectral weighting functions:

TABLE 1

PROPERTIES OF WEIGHTING FUNCTION

Weighting Function	Peak Sidelobe db	Loss db	Mainlobe width (relative)	Sidebbe decay function
Uniform	-13.2	0	1.0	1/t
$0.33+0.66\cos^2(\pi \ell/B)$	-25.7	0.55	1.23	1/t
$\cos^2(\pi \ell/B)$	-31.7	1.76	1.65	$1/t^3$
Taylor ($\bar{n}$ = 8)	-40	1.14	1.41	1/t
Dolph-Chebyshev	-40	....	1.35	1
$0.08+0.92\cos^2(\pi \ell/B)$ (Hamming)	-42.8	1.34	1.50	1/t

B = bandwidth

III. RADAR PROBLEMS

A. PROBLEM #1: DETECTION

Consider the design of a shipboard search radar. False alram rate is an annoying problem for the radar operator. Threshold detection is to be used. The bandwidth of the I-F amplifier is $B_{I-F} = 4$ MHz. Calculate the threshold-to-rms noise voltage ( ) for a mean time between false alarms, T_{fa}, of:

a) 5 minutes

b) 50 minutes

c) 500 minutes

Solution

From Eq. (2.26) (Skolnik, pg. 25)

$$T_{fa} = \frac{1}{B_{IF}} \exp \frac{V_T^2}{2\psi_o} \tag{1}$$

where:

T_{fa} = false alarm time;

B_{IF} = bandwidth of the amplifier;

V_T = threshold voltage;

$\psi_o^{1/2}$ = rms noise voltage.

From Eqn. (1),

$$V_t/\sqrt{\psi_o} = 2\{\ln(T_{fa} \cdot B_{IF})\}^{1/2} \tag{2}$$

Substituting in Eq. (2) the values of T_{fa} and B_{IF} we find for:

Part a:

threshold-to-rms noise voltage: $V_T/\sqrt{\psi_o}$ = 6.466 (numeric) or 8.106 db.

Part b:

threshold-to-rms noise voltage: $V_t/\sqrt{\psi_o}$ = 6.813 (numeric) or 8.333 db.

Part c:

threshold-to-rms noise voltage: $V_t/\sqrt{\psi_o}$ = 7.143 (numeric) or 8.538 db.

B. PROBLEM #2: DETECTION LOSS

For a non-fading target, with probability of detection $P_d = 0.99$ and a false alarm number $n_f = 10^{12}$ with non-coherent integration, find the collapsing loss, if

a) $n = 10$ and $m = 10$

b) $n = 10$ and $m = 90$

Solution

From Figure 2.8(a) (Skolnik, pg. 31) we can find the integration loss for $L_i(m+n)$ and $L_i(n)$, since the probability of detection P_d and the false alarm number n_f are known.

$$L_i(m+n) = L_i(10+10) = L_i(20) = 1.9 \text{ db}$$

$$L_i(n) = L_i(10) = 1.3 \text{ db}$$

From Eq. (2.52) (Skolnik, Pg. 59),

$$L_i(m,n) = \frac{L_i(m+n)}{L_i(n)} \tag{3}$$

where:

$L_i(m,n)$ = collapsing loss;

$L_i(m+n)$ = integration loss for m+n pulses;

$L_i(n)$ = integration loss for n pulses.

Substituting in Eq. (3), the values of $L_i(20)$ and $L_i(10)$, we get the collapsing loss,

$$L_i(10,10) = 1.9 - 1.3 = 0.6 \text{ db or } 1.14815 \text{ (numeric)}$$

Part b:

From the same Figure 2.8(a), we can find that

$$L_i(m+n) = L_i(90+10) = L_i(100) = 4.1 \text{ db}$$

$$L_i(n) = L_i(10) = 1.3 \text{ db}$$

Substituting in Eq. (3) the values of $L_i(100)$ and $L_i(10)$ we get the collapsing loss

$$L_i(90,10) = 4.1 - 1.3 = 2.8 \text{ db or } 1.905 \text{ numeric.}$$

C. PROBLEM #3: MAXIMUM RANGE

A pulse radar uses a magnetron with a peak power P_t = 1.0 Mw, a pulse width τ = 1.0 μs, and a pulse repetition frequency f_p = 250 Hz. It operates at λ = 10 cm, and the effective antenna aperture A_e = 200 m^2. Ten pulses are integrated after

detection. The receiver noise figure $F_n = 10$ db and it has a noise bandwidth $B_n = 1.0$ MHz. Plumbing losses $L_p = 3.0$ db and the beam shape $L_{bs} = 2.0$ db. Exponential (continuous) integration is used, resulting in a reduction by a factor of 0.85 in the integration efficiency. Threshold detection is used with a false alarm probability $P_{fa} = 10^{-9}$.

a) Find the maximum unambiguous range

b) Find the maximum range for a detection probability $P_d = 0.99$ on a target with $\sigma_{av} = 1\ m^2$ average cross section, if fading follows the Rayleigh power distribution law and occurs from pulse to pulse (case 2). Assume there is no atmospheric attenuation.

Solution:

From Eq. 1.2 (Skolnik, Pg. 3) the maximum unambiguous range is

$$R_{unamb} = \frac{c}{2f_p} \tag{4}$$

where:

c = velocity of the light = 3×10^8, m/s;

f_p = pulse repetition frequency, Hz;

so,

$$R_{unamb} = \frac{3 \times 10^8}{2 \times 250} = 6 \times 10^5 \text{ m} = 600 \text{ km.}$$

Part b:

From Eq. 2.54 (Skolnik, Pg. 62) the maximum radar range is given by the formula,

$$R_{max}^4 = \frac{P_{av}\, G A\, \rho_a\, \sigma\, n\, E_i(n)}{(4\pi)^2\, k T_o\, F_n\, (B_n \tau)\, f_p\, (S/N)_1\, L_s} \tag{5}$$

where:

R_{max}	=	maximum radar range, m;
G	=	antenna gain;
A	=	antenna aperture, m^2
ρ_a	=	antenna efficiency;
n	=	number of hits integrated;
$E_i(n)$	=	integration efficiency (less than unity);
L_s	=	system losses (greater than unity) not included in other parameters;
σ	=	radar cross section of target, m^2;
F_n	=	noise figure;
k	=	Boltzmann's constant = 1.38×10^{-23} J/deg.;
T_o	=	standard temperature = 290 k;
B_n	=	receiver bandwidth, Hz;
τ	=	pulse width, seconds;
f_p	=	pulse repetition frequency, Hz;
$(S/N)_1$	=	signal-to-noise ratio required at receiver output (based on signle-hit detection).

From Eq. 2.43 (Skolnik, Pg. 52),

$$P_{av} = P_t\, \tau\, f_p \tag{6}$$

where:

P_{av}	=	the average radar power, w;
P_t	=	the average transmitter power, w;

τ = pulse width, s;

f_p = pulse repetition frequency, Hz.

From Eqn. 7.9 (Skolnik, Pg. 227),

$$G = \frac{4\pi A_e}{\lambda^2} = \frac{4\pi\rho_a A}{\lambda^2} \tag{7a}$$

$$A_e = A\rho_a \tag{7b}$$

where:

A_e = effective area;

A = physical area of antenna;

ρ_a = antenna aperture efficiency;

λ = wavelength.

The total system losses are:

$$L_s = L_p + L_{bs} \tag{8}$$

where:

L_s = system losses, db;

L_p = plumbing losses, db;

L_{bs} = beam shape, db.

So,

$$L_s = 3 + 2 = 5 \text{ db} = 3.1622$$

From Fig. 2.7 (Skolnik, Pg. 28), the signal-to-noise ratio $(S/N)_1 \doteq 15.9$ db, for probability of detection $P_d = 0.99$

and false alarm probability $P_{fa} = 10^{-9}$. From Fig. 2.23 (Skolnik, Pg. 48) the additional signal-to-noise ratio $(S/N)_{1add} \doteq 17.2$ db for case 2 and $P_d = 0.99$. So,

$$(S/N)_{1TOT} = (S/N)_1 + (S/N)_{1add} \tag{9}$$

so $(S/N)_{1TOT} = 15.9 + 17.2 = 33.1$ db or 2041 (numeric). From Fig. 2.24 (Skolnik, Pg. 49) the integration improvement factor $I_i(n) = 25$ db $= 316.22$ (numeric),

$$I_i(n) = nE_i(n) \tag{10}$$

where:

$I_i(n)$ = integration improvement factor, db;

$E_i(n)$ = integration efficiency;

n = number of hits integrated.

From Eq. (10),

$$E_i(n) = \frac{I_i(n)}{n} \tag{10a}$$

and because we have a reduction by 0.85 in the integration efficiency, Eq. (10a) becomes

$$E_i(n) = \frac{I_i(n)}{n} \times 0.85 \tag{10b}$$

so

$$E_i(n) = \frac{316.22}{10} \times 0.85 = 26.537$$

Now substituting Eqs. (6), (7a), (7b), (8), (9), (10) in Eq. (5), and simplifying, we get

$$R_{max} = \left[\frac{P_t \, A_e^2 \, \sigma \, n \, E_i(n) \, 0.85}{(4\pi) \, k \, t_o \, F_n \, B_n \, \lambda^2 (S/N)_{1TOT} \, L_s} \right]^{1/4} \tag{11}$$

$$= \left[\frac{(1 \times 10^6) \times (200)^2 \times 1 \times 26.537 \times 10}{(4\pi) \times 1.38 \times 10^{-23} \times 290 \times 10 \times (1 \times 10^6) \times (0.1)^2 \times 2041.73 \times 3.1622} \right]$$

$$= 758.57 \text{ km}$$

D. PROBLEM #4: FM-RANGING, DOPPLER

A CW FM radar operates at f_o = 10.5 GHz. The frequency increases at a rate $\dot{f}_o$ = 2 GHz/sec for T = 990 microseconds, and then returns to its original value in T_r = 10 microseconds.

a) Calculate the frequency shift of the echo from a target at a range R = 5000 yards

b) Calculate the range error due to doppler shift if the closing rate of the radar and target U_r = 25 ft/sec.

Solution:

From Eq. 3.10 (Skolnik, Pg. 82)

$$f_r = \dot{f}_o T \tag{11a}$$

$$f_r = \dot{f}_o \, 2R/C \tag{11b}$$

where:

f_r = the beat frequency due to the target range;

$\dot{f}_o$ = rate that the frequency changes;

T = rate that takes an echo signal to return;

R = target range;

C = speed of light = 3×10^{8} w/d.

So, from Eq. (11b) the frequency shift is:

$$f_r = \frac{2 \times 10^{9} \times 2 \times 5.000 \times 0.914}{3 \times 10^{8}} = 60.933 \text{ kHz}$$

Part b:

From Eq. 3.2(a) (Skolnik, Pg. 69)

$$f_d = \frac{2U_r}{\lambda} \tag{12}$$

where:

f_d = doppler frequency shift, Hz;

U_r = relative velocity, m/s;

λ = wavelength of radiated energy, m.

So, from Eq. (12),

$$f_d = \frac{2 \times 25 \times 0.305 \times 10.5 \times 10^{9}}{3 \times 10^{8}} = 533.75 \text{ Hz}$$

The range error is given by the

$$\Delta R = \frac{R \times f_d}{f_r} \tag{13}$$

So,

$$\Delta R = \frac{5000 \times 533.75}{60.933 \times 10^{3}} = 43.798 \text{ yards} = 40.03125 \text{ m}$$

or 0.4% m = 0.4379% yards.

E. PROBLEM #5: BLIND SPOTS IN DOPPLER

A 9 GHz radar operates with a pulse width $\tau = 1\ \mu s$ and a PRF $f_p = 1000$ Hz.

a) What is the first blind speed?

b) A jet aircraft is flying $U_{air} = 600$ knots. If the above radar detects the aircraft, will there be a doppler ambiguity? Explain.

Solution:

From Eq. 4.8 (Skolnik, Pg. 108)

$$U_{lb1} = \frac{\lambda f_p}{2} \tag{14}$$

where:

U_{lb1} = the first bline speed, m/s;

λ = wavelength, Hz;

f_p = pulse repetition frequency, Hz.

So, the first blind speed is

$$U_{lb1} = \frac{c}{f}\frac{f_p}{2} = \frac{3 \times 10^8 \times 1000}{2 \times 9 \times 10^9} = 16.66 \text{ m/s} = 32.36 \text{ knots}$$

Part b:

Since $U_{air} = 600$ knots $> U_{lb} = 32.36$ knots, there will be a doppler ambiguity.

F. PROBLEM #6: MTI

A 1000 Hz PRF radar with a clutter spectral width $\sigma_c = 10$ Hz, uses a 3 pulse delay line canceller, with optimal weighting. What is the MTI improvement factor in db?

Solution:

$$\frac{\text{Clutter spectral width}}{\text{radar PRF}} = \frac{\sigma_c}{f_p} = \frac{10}{1000} = 0.01 \qquad (15)$$

From Figure 4.25 (Skolnik, Pg. 124) the MTI improvement factor I = 55 db, for a 3-pulse delay-line canceller, with optimum weights, and $\sigma_c/f_p = 0.01$.

G. PROBLEM #7: POWER, NOISE POWER, S/N

The following data for a pulse radar is available:

Peak power p_p = 200 kw;

Pulse repetition rate r_p = 300 Hz;

Pulse width τ = 60 microsec;

False alarm time T_{fa} = 2.2 hrs;

Receiver noise figure r_n = 65 db;

Transmitter frequency, f_o = 400 MHz;

IF: F_{IF} = 120 MHz;

IF bandwidth: B_{IF} = 1.25 MHz;

Antenna power gain: G_a = 21 db;

Minimum detectable signal MDS = -115 dbm.

a) What is the average output power?

b) What is the noise power? How does it compare to the minimum detectable signal? What is the rms threshold power to noise ratio if no pulse integration is performed?

c) For a target of σ = 1 sq. m cross section which fluctuates from pulse to pulse according to the one-plus-Rayleigh power distribution, what is the minimum signal to noise ratio required to achieve a probability of detection if n = 30 pulses are integrated after post-detection?

d) Use $(S/N)_{min}$ = 4 db as the answer to the above problem instead of the solution you obtained. Assume the total system losss L_s = 1 db. What is the maximum range of the radar for the detection of the target described above with probability of detection P_d = 0.5?

e) If the radar has a minimum range R = 10.5 km, what is its approximate TR recovery time?

Solution:

Part a:

From Eq. 2.43 (Skolnik, Pg. 52) the average output power may be written as:

$$P_{av} = P_p \times \tau \times f_p \tag{16}$$

where:

P_p = peak power, w;

τ = width of the transmitted rectangular pulses, sec.;

f_p = pulse repetition rate.

So,

$$P_{av} = (200 \times 10^3) \times (60 \times 10^{-6}) \times 300 = 3.6 \text{ kw}$$

Part b:

From Eq. 2.2 (Skolnik, Pg. 18) the noise power N_n generated by a receive of bandwidth B_{IF} at a temperature T (degrees Kelvin) is equal to

$$N_n = k\ T\ B_{IF} \tag{17}$$

where:

k = Boltzmann's constant = 1.38×10^{-23} J/deg.;

T = 290° Kelvin (room temperature).

So,

$$N_n = (1.38 \times 10^{-23}) \times 290 \times (1.25 \times 10^{6}) = 5 \times 10^{-15} \text{ watts}$$

$$= -113 \text{ dbm.}$$

The noise power N_n = -113 dbm > MDS = -115 dbm.

From Eq. 2.26 (Skolnik, Pg. 25) the threshold power to noise ratio is equal to

$$\frac{V_T^2}{2\psi_o} = \ln(T_{fa} \times B_{IF}) \tag{18}$$

where:

T_{fa} = false alarm time;

B_{IF} = bandwidth of the amplifier;

V_T = threshold voltage,

$\psi_o^{1/2}$ = rms noise voltage.

So,

$$\frac{V_T^2}{2\psi_o} = \ln(22 \times 3600 \times 1.25 \times 10^{6}) = \ln(9.9 \times 10^{9}) = 13.6 \text{ db}$$

Part c:

From Figure 2.7 (Skolnik, Pg. 28), for probability of detection $P_d = 0.5$ and false alarm probability $P_{fa} = \frac{1}{T_{fa} \times B_{IF}} = \frac{1}{2.2 \times 3600 \times 1.25 \times 10^6} \doteq 10^{-10}$, the signal-to-noise ratio $(S/N)_1 \doteq 13.6$ db.

From Figure 2.23 (Skolnik, Pg. 48) the additional signal-to-noise ratio for one pulse is $(S/N)_{10dd} = 1.0$ db. So,

$$(S/N)_{1TOT} = (S/N)_1 + (S/N)_{10dd} = 13.6 + 1.0 = 14.6 \text{ db}$$

(case 4).

From Figure 2.24 (Skolnik, Pg. 49) for $P_d = 0.5$ and for $n = 30$ integrated pulses the integration improvement factor $I_i(n) = 11.4$ db.

The minimum signal to noise ratio $(S/N)_{30} = \frac{(S/N)_{1TOT}}{I_i(n)} =$ 14.6 (db) - 11.4 (db) = 3.2 db.

Part d:

The basic radar range equation may be written as:

$$R^4_{max} = \frac{P_t \, G_a^2 \, \lambda^2 \, \sigma}{(4\pi)^3 \, k \, T \, B_{IF} \, F_n (S/N)_{30} \, L_s} \tag{19}$$

A simple way to handle the mathematics is to convert all of the factors to db and then add and subtract.

Numerator

$P_t = 200 \times 10^3$ watts	=	+53.0 dbw
$G_a^2 = 2 \times 21$ db	=	+42.0 db

$\lambda^2 = \left(\frac{3 \times 10^8}{400 \times 10^6}\right)^2 = 0.5625 =$ -12.5 db (negative because of characteristic)

$\sigma = 1$ sq. m $=$ + 0.0 db

ΣN = +92.5 dbw

Denominator

$(4\pi)^3 = 3 \times 10.97$ db $=$ + 32.9 db

$kT_o = 4 \times 10^{-21}$ W/Hz $=$ - 204 dbw

$B_{IF} = 1.25 \times 10^6$ Hz $=$ + 60.9 db

$F_n = 6.5$ db $=$ + 6.5 db

$(S/N)_{30} = 4$ db $=$ + 4.0 db

$L_s = 1$ db $=$ + 1.0 db

ΣD = -98.7 dbw

$$R_{max} = \frac{1}{4}[\Sigma N - \Sigma D] = \frac{1}{4}[92.5 - (-987)] = 47.8 \text{ db}$$

$$= 60.25 \text{ km}$$

Part e:

The recovery time is equal to

$$T_R = \frac{2R}{c} - \tau = \frac{2 \times 10.5 \times 10^3}{3 \times 10^8} - 60 \times 10^6 = 10 \ \mu\text{sec.}$$

H. PROBLEM #8: MTI-CHAFF DISCRIMINATOR

A 6 GHz, 1000 Hz PRF MTI radar uses a double delay line canceller against chaff. What is its improvement factor in db?

<u>Solution</u>:

The improvement factor, for a double canceller is given in Eq. 4.26 (Skolnik, Pg. 133) and is equal to:

$$I_{2c} = \frac{a^2 f_p^4}{2\pi^4 f_o^2} \tag{20}$$

where:

f_p = the pulse repetition frequency, Hz;

f_o = the operating frequency, Hz;

π = 3.14159

a = parameter dependent upon clutter.

The parameter $a = c^2/8\sigma_u^2$, where $c = 3 \times 10^8$ m/s, σ_u = the rms velocity spread.

From Figure 13 (Skolnik, Pg. 16-17), the rms velocity spread varies from $\sigma_{U1} = 0.4$ m/s to $\sigma_{U2} = 1$ m/s, so

$$a_1 = \frac{c^2}{8\ \sigma_{U1}^2} = \frac{(3 \times 10^8)^2}{8 \times (0.4)^2} \doteq 7 \times 10^{16} \quad \text{and}$$

$$a_2 = \frac{c^2}{8\ \sigma_{U2}^2} = \frac{(3 \times 10^8)^2}{8 \times (1)^2} = 1.125 \times 10^{16}$$

So, the improvement factor for $a_1 = 7 \times 10^{16}$ is

$$I_{2c_1} = \frac{a_1^2 f_p^4}{2\pi^4 f_o^4} = \frac{(7 \times 10^{16})^2 \times (1000)^4}{2 \times \pi^4 \times (6 \times 10^9)^4}$$

$$= 1.94 \times 10^4 = 43 \text{ db}$$

and for $a_2 = 1.125 \times 10^6$, is

$$I_{2c_2} = \frac{(1.125 \times 10^{16})^2 \times (1000)^4}{2 \times \pi^4 \times (6 \times 10^9)^4} \doteq 501.18 = 27 \text{ db}$$

So, the improvement factor is from 43 db to 27 db.

I. PROBLEM #9: MTI-CHAFF-CLUTTER DISCRIMINATOR

Find the approximate reduction in the improvement factor, I, in db from the near ideal case, when the PRF $f_p = 300$ Hz, and the clutter doppler frequency is shifted on the average by $f_e = 30$ Hz and the rms clutter spread is approximately $_c = 3$ Hz. Assume a three pulse canceller.

<u>Solution</u>:

$$\text{The } \frac{\text{rms clutter spread}}{\text{pulse repetition freq.}} = \frac{3}{300} = 0.01.$$

Also, the

$$\frac{\text{mean freq. of the clutter spectrum}}{\text{pulse repetition freq.}} = \frac{30}{300} = 0.1$$

So, from Figure 4.34 (Skolnik, Pg. 141) the reduction of the improvement factor I = 24 db, for the near ideal case and for three pulse canceller.

J. PROBLEM #10: PHASED ARRAY-BW

The radar AN/FPS - 108 (COBRA DANE) is designed to scan up to 60 degrees off the antenna center axis. Assume the separation between two adjacent active array elements d = 210 cm and the radar is operating at f_o = 1250 MHz. The diameter of the phase array antenna is D = 29 m.

a. What is the phase difference between two array elements along the horizontal direction if the antenna is steered along this direction, 10 degrees off center?

b. What is the beamwidth at this angle, if each array element has the same output power?

Solution:

Part a:

In order for the main beam of the radiation pattern to be positioned at an angle θ_o = 10°, the phase shift between adjacent elements of the array must be:

$$\phi = 2\pi \frac{d}{\lambda} \sin \theta_o \tag{21}$$

where:

d = separation between two adjacent elements, m;

λ = wavelength, m;

θ_o = degrees of center, of the position of the antenna.

So, the phase difference between two adjacent array elements

$$\phi = \frac{2 \cdot \pi \cdot 0.2 \cdot 1250 \times 10^6}{3 \cdot 10^8} \sin (10) = 52.09° \text{ (0.9 radians)}$$

Part b:

From Eq. 8.13 (Skolnik, Pg. 284) the half-power beamwdith is equal to:

$$\theta_B = \frac{0.866\ \lambda}{N\ d\ \cos\ \theta_o} \tag{22}$$

where:

- N = number of elements = 1;
- d = diameter of phase array antenna, m;
- θ_o = degrees of center, of the position of the antenna;
- λ = wavelength, m.

So, the beamwidth at $\theta_o = 10°$, for the same output power of each array element is equal to:

$$\theta_B = \frac{0.866 \times 3 \times 10^8}{1 \times 29 \times 1250 \times 10^6 \times \cos\ 10} = 7.28 \times 10^{-3}\ \text{radians}$$

$$= 0.417°$$

K. PROBLEM #11: PULSE RADAR-RMAX

Estimate the maximum range R_{max} for the following pulse radar system:

Antenna gain	G_a	= 21 db;
Peak power	P_t	= 2 MW;
Frequency	f_o	= 500 MHz;
Ambient Temperature	T_a	= 62°F
Receiver bandwidth	B_n	= 1 MHz;

Target: Jet airliner with $\sigma = 5\ m^2$;

Receiver noise figure F_n = 10dbw;

Pulselength τ = 3 microsec.;

$I_i(n) = nE_i(n) = 16.5$ db.

It is desired that the probability of detection be at least 90% and that the false alarm rate not exceed 10^{-11}. Assume system losses are compatible with an airport surveillance radar system L_s = 6 db.

Solution:

The basic radar range equation may be written as:

$$R^4_{max} = \frac{P_t\ G_m^2\ \lambda_o^2\ \sigma\ n\ E_i(n)}{(4\pi)^3\ k\ T_o\ B_n\ F_n (S/N)_1\ L_s} \tag{23}$$

For the numerator:

$P_t = 2 \times 10^6$ watts =	+ 63 dbw
$G_o^2 = 2 \times 21$ dbi =	+ 42 db
$\lambda_o^2 = 0.36\ m^2$ =	- 4.4 db
$\sigma = 5m^2$ =	+ 7.0 db
$nE_i(n)$ = 165 db =	+ 16.5 db
Σ N	= + 124.1 dbw

Denominator:

$(4\pi)^3 = 3 \times 10.97$ db =	+ 32 db
$kT_o = 4 \times 10^{-21}$ w/Hz =	- 204 dbw
$B_n = 10^6$ Hz =	+ 60 db
F_n = 10 db =	+ 10 db

$(S/N)_1 = 15.4$ db $=$ $+\ 15.4$

$L_s = 6$ db $=$ $+\ 6$ db

ΣD $= -79.7$ dbw

$$R_{max} = \frac{1}{4}[\Sigma N - \Sigma D] = \frac{1}{4}[124.1 - (-79.7)]$$

$$= \frac{203.8}{4} \text{ db} = 51 \text{ db}$$

$$R_{max} = 122.5 \text{ km} = 67.2 \text{ n. miles}$$

L. PROBLEM #12: TWS, PROBABILITY OF DETECTION

The AN/SPC-10 radar has the following operating parameters:

Frequency	5600 MHz
Power (peak)	200 Lw
PRF	625 Hz
Pulse width	1.4 microsec.
Antenna scan rate	16 Hz
Azimuth beamwidth (3 db)	1.5 degrees
Antenna gain)	33 db
Receiver noise bandwidth	1 MHz
Receiver noise figure	9.88 db
System losses (ahead of receiver)	5 db
False alarm time	2 days
Antenna noise temperature	75 degrees K
PPI display + operator	

(a) Calculate the number of hits/scan on a point target

(b) Determine the single pulse S/N in db required to achieve a detection probability of 0.95

(c) Determine the integration improvement factor

(d) Calculate the minimum detectable signal power in dbw

(e) Calculate the peak effective radiated power in dbw

(f) Calculate the effective area of the antenna in square meters

(g) Calculate the maximum free space detection range in km for a detection probability of 0.95 (with false alarm time = 2 days) on a 0 dbsw non-fluctuating point target

Solution:

Part a:

The number of pulses n_B returned from a point target as the radar antenna scans through its beamwidth is

$$n_B = \frac{\theta_B}{2 \times 180} T_s f_p = \left(\frac{1.5}{360}\right) \times \left(\frac{60}{16}\right) \times (625)$$

$$= 9.77 \text{ hits/scan}$$

Part b:

The probability of false alarm is

$$P_{fa} = \frac{1}{T_{fa} B_{IF}} = \frac{1}{(2 \times 24 \times 3600 \text{ sec})(10^6 \text{ Hz})} = 58 \times 10^{-12}$$

From Figure 2.7 (Skolnik, Pg. 28) the signal-to-noise (power) ratio is $(S/N)_1 \doteq 16$ db for $P_d = 0.95$ and $P_{fa} = 58 \times 10^{-12}$

Part c:

From Figure 2.8(a) (Skolnik, Pg. 31), incoherent integration of 9 pulses gives $I_i(9) = 7 = 8.4$ db.

Part d:

The minimum detectable signal power is given as

$$\text{MDS} \quad k\,T_o\,B_n\,F_n = 138 \times 10^{-23} \times 290 \times 10^{6} \times 9.727 = -134.1 \text{ dbw}$$

Part e:

The peak effective radiated power is equal to:

$$P_{eff} = P_t\,G_t \tag{24}$$

where:

$$P_t = 200 \times 10^{3} \text{ N} = 53 \text{ db (transmitter power);}$$

$$G_t = 33 \text{ db (antenna gain).}$$

So,

$$P_{eff} = 53 + 33 = 86 \text{ dbw.}$$

Part f:

The antenna effective area is equal to:

$$A_e = \frac{\lambda^2}{4\pi} \times G = \frac{(5.35 \times 10^{-2})^2}{4\pi} \times 2000$$

$$A_e = 0.456 \text{ m}^2 \approx -3.4 \text{ dbsm}$$

Part g:

The maximum radar range R_{max} is equal to

$$R_{max} = \frac{P_t\,G_t\,A_e\,\sigma\,I_i(n)}{(4\pi)^2\,k\,T_o\,\left(\frac{T_a + T_e}{T_o}\right) B_n\,(S/N)_1\,L_s} \tag{25}$$

(1) $10 \log_{10}(4\pi)^2 = 22$ db

(2) $10 \log\left(\frac{T_a + T_e}{T_o}\right) = 10 \log_{10}\left(\frac{75 + 2530}{290}\right) = 9.53$ db

$$10 \log_{10}(R^4_{max}) = [86 \text{ dbw} - 3.4 \text{ db} + 0 \text{ dbsw} + 8.4 \text{ db}] - [22 \text{ db} - 204 + 9.53 + 60 + 16 + 5]$$

$$10 \log_{10} R^4_{max} = 182.5 \text{ db}$$

$$R_{max} = 10^{4.56} = 36{,}307 \text{ m.}$$

So,

$$R_{max} = 36.3 \text{ km } (P_d = 0.95 \text{ on } 0 \text{ dbsw target})$$

M. PROBLEM #13: RECEIVER'S BANDWIDTH

A 10 GHz CW doppler radar of single sideband superheterodyne design, has the block diagram shown in Figure 3.4, pg. 75 of [Ref. 2]. The radar is to be designed to measure the speed of vehicles with RCS = 10 dBsm traveling at velocities up to 100 mi/hrs at ranges up to 1/2 miles. For reliable operation, a signal-to-noise ratio and 15 db is required at the output of the IF amplifier. The receiver noise figure is F = 7.25 db, plumbing loss is 2 db and T_a = 300 degrees K. The transit and receive antennas have gains of 20 db each.

(a) Calculate the required receiver bandwidth

(b) Calculate the required receiver input signal power in dbm

(c) Calculate the one way free space loss in db for a target vehicle at a range of 1/2 miles

(d) Calculate the required transmitter output power

Solution

Part a:

$$U_{rmax} = 100 \text{ mi/hrs} = 44.72 \text{ m/sec}$$

$$f_d = \frac{2U_r f_o}{c} = \frac{2 \times 44.72 \times 10^{10} \text{ Hz}}{3 \times 10^8} = 2981 \text{ Hz}$$

$$B = 2f_d = 5962 \text{ Hz} \doteq \text{GkHz}$$

Part b:

The receiver input signal power is equal to:

$$S_{in} = k(T_a + T_e)B(S/N)_{out} = k\,T_o\left(\frac{T_a + T_e}{T_o}\right)B(S/N)_{out}$$

(1) $kT_o = -174$ dbw/Hz

(2) $\frac{T_a + T_e}{T_o} = \frac{300 + 1250}{290} = 5.34 = 7.28$ db

(3) $B = 6$ kHz $= 37.8$ db Hz

So,

$$S_{in} = -174 + 7.3 + 37.8 + 15 = -114 \text{ dbm.}$$

Allocate 1/2 of the plumbing loss to the receiver (1 db).

Taking this into account, we would require

$$S_{in} = -113 \text{ dbm.}$$

Part c:

The one way free space loss is equal to

$$L_{bf} = 10 \log_{10}\left(\frac{4\pi R}{\lambda}\right)^2 = 10 \log_{10}\left(\frac{4\pi \times 805 \text{ m}}{0.03}\right)^2$$

$$L_{bf} = 110.6 \text{ db.}$$

Part d:

The required transmitter output power is:

$$P_t = P_{eff} - G_\sigma + (2L_{bf} - G_r - G_t) \tag{26}$$

$$G_\sigma = 10 \log_{10} \frac{4\pi\sigma}{\lambda^2} = 41.4 \text{ db}$$

So from Eq. (26) we get

$$P_t = -113 \text{ dbm} - 41.4 \text{ db} + (2 \times 110.6 - 20 - 20)$$

$$P_t = 26.8 \text{ dbm}$$

If we assign the remaining 1 db of plumbing loss to the transmitter, we obtain

$$P_t = 27.8 \text{ dbm} = 603 \text{ m Watts.}$$

N. PROBLEM #14: BLIND SPEED--MTI

An 1 GHz MTI radar operates with a 4 period stagger T1:T2:T3:T4 = 25:30:27:31 and $T_{avg} = 0.001$ sec. Calculate the periods T1 ~ T4 and the first blind speed in knots.

Solution:

$$\frac{T1 + T2 + T3 + T4}{4} = T_{avg} = 10^{-3} \text{ sec} \tag{27}$$

$$\frac{25}{T1} = \frac{30}{T2} = \frac{27}{T3} = \frac{31}{T4} \tag{28}$$

Substituting Eq. (28) in Eq. (27, we have

$$\frac{25}{25} T1 + \frac{30}{25} T1 + \frac{27}{25} T1 + \frac{31}{25} T1 = 10^{-3}$$

$$\frac{113 \ T1}{100} = 10^{-3}$$

$$T1 = 884.96 \ \mu\text{sec}$$

$$T2 = 1061.9 \ \mu\text{sec}$$

$$T3 = 955.76 \ \mu\text{sec}$$

$$T4 = 1097.35 \ \mu\text{sec}$$

The first blind speed is (in knots)

$$U_1 = \frac{\lambda f_p}{1.02}\left(\frac{25 + 30 + 27 + 31)}{4}\right) = \frac{0.3 \times 10^3}{1.02} = 8309 \text{ knots}$$

O. PROBLEM #15: MTI WEIGHTS--DELAYS

An MTI radar operates at a frequency 1 GHz with PRF = k KHz.

(a) Calculate the first blind speed in knots

(b) Sketch a block diagram of a 4 pulse canceler for this radar. Show correct weights and delays

(c) Calculate the clutter rejection in db at a frequency of 25 Hz for the 4 pulse canceler

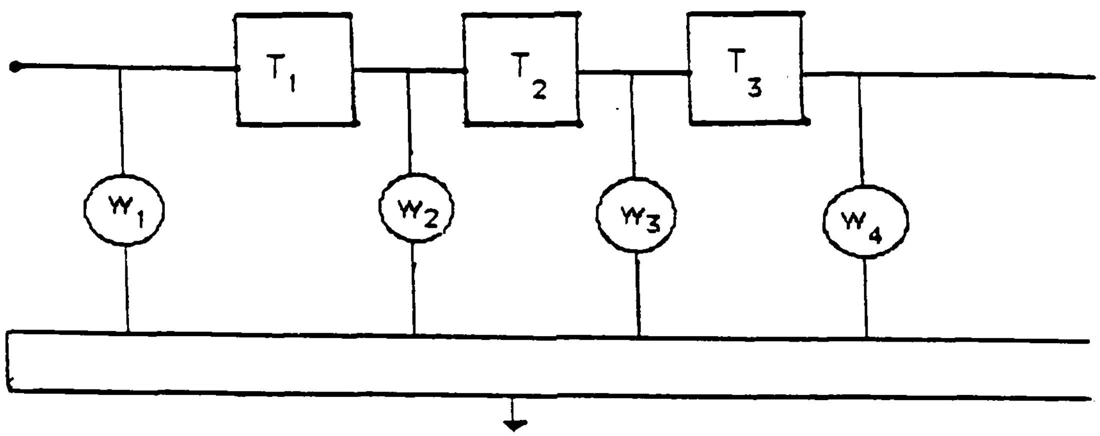
(d) If a target with a radial velocity of 200 knots is viewed with this radar, of what frequency will the bipolar video fluctuate?

Solution:

Part a:

$$U_{1b1} = \frac{\lambda f_p}{1.02} = \frac{3 \times 10^8 \times 1000}{10^9 \times 1.02} = 294.118 \text{ knots}$$

Part b:



$$T1 = T2 = T3 = 10^{-3} \text{ sec}$$

$$W_i = (-1)^{i-1} \frac{n!}{(n-i+1)^1 (i-1)!} \qquad \begin{array}{l} i = 1,2,3,4 \\ n = 3 \end{array}$$

$$W1 = (-1)^0 \frac{3!}{3!0!} = 1$$

$$W2 = (-1)^1 \frac{3!}{2!1!} = -3$$

$$W3 = (-1)^2 \frac{3!}{1!2!} = 3$$

$$W4 = (-1)^3 = \frac{3!}{0!3!} = -1$$

Part c:

The relative response of the 4 pulse canceler is

$$\frac{H(f)}{H(f_p/2)} = \sin^3(\pi f T)$$

For F_d = 25 Hz, the clutter rejection is

$$-\ 20 \log_{10} \sin^3(\frac{\pi\ 25}{1000}) = -60 \log(.078)$$

$$R_{ejection} = 66.3 \text{ db}$$

Part d:

The bipolar video fluctuates at the doppler frequency

$$f_d = \frac{2U_r f_o}{c}$$

if U_r is in knots,

$$f_d = \frac{1.03\ U_r}{\lambda} = \frac{1.03 \times 200}{.3}$$

$$f_d = 686.7 \text{ Hz}$$

IV. EW PROBLEMS

A. PROBLEM #1: DETECTION RANGE, UNAMBIGUOUS RANGE

A shipboard surface search radar has the following characteristics:

Frequency	f_o = 5600 MHz
Pulse width (long)	T_ℓ = 1.3 s
Pulse width (short)	T_s = 0.25 s
Power output (peak)	P_t = 200 kw
PRF	f_p = 650 Hz
Bandwidth (long pulse)	B_{re} = 1 MHz
Bandwidth (short pulse)	B_{rs} = 5 MHz
Antenna scan frequency	W_m = 16 RPM
Azimuth beamwidth	ϕ_B = 1.5°
Elevation beamwidth	θ_B = 14°
Antenna noise temperature	T_u = 75 degrees k
False alarm probability	p = 1E-11
Receiver noise figure	F_n = 10 db

The radar polarization is linear and deflections are made by an operator using a PPI display.

(a) Calcualte the maximum detection range for a 1 square meter non-fluctuating target, assuming that a detection probability P_d = 0.95 is required. Neglect the effect of reflections from the sea surface

(b) Calcualte the maximum unambiguous range of the radar

(c) Calculate the range at which an aircraft with RCS = 10 dBsm will be detected with P_d = 0.95. Assume the target is non-fluctuating and the radar is operating in the long pulse mode.

(d) Assume the radar antenna is 50 ft above the sea surface. For the case where the above aircraft is at the maximum detection range, calculate the minimum altitude at which the radar can see the target in a standard atmosphere

(e) Suppose that the radar signal is received by the aircraft above using a circular polarized antenna with 0 db gain. What is the single pulse power (in dbm) at the antenna output terminals, when the aircraft is at the maximum detection range? (Assume system loss L_s = 3 db)

(f) Calculate the camouflage factor c, for this radar as given by Boyd et al., for the long pulse mode

(g) Suppose the aircraft above carries a noise jammer and transmits a 30 MHz, circular, polarized spot noise signal, covering the radar passband

Assuming a J/S = 5 db is required to work the target, calculate the Jammer output power required to achieve a 10 nuatical miles burnthrough range, when the radar is operated in the long pulse mode, if a 0 db gain jamming antenna is used.

Solution:

The maximum detection range is equal to

$$R_{max} = \left[\frac{P_t\ G_a\ A_e\ \sigma\ n\ E_i(n)}{(4\pi)^2\ k\ T_a+T_e)\ B_n\ (S/N)_{1max}}\right]^{1/4} \qquad (1)$$

where:

(1) P_t = peak output power = 200×10^3

(2) G_a = antenna gain = $\frac{41250}{\theta_B \phi_B} = \frac{41250}{14 \times 1.5}$

$\doteq$ 1964 = 32.9 db

(3) A_e = antenna aperture = $\dfrac{\lambda^2 G_a}{4\pi} = \dfrac{c}{f_o}\;\dfrac{G_a}{4\pi}$

$$= \left(\frac{3 \times 10^8}{5600 \times 10^6}\right) \frac{1964}{4\pi} = 0.449 \text{ w}^2$$

(4) = radar cross section of target = 1 m^2

(5) Number of hits integrated = $\dfrac{\phi_B f_p T_s}{2\pi}$

$$= \frac{1.5}{360} \times (650 \text{ sec}^{-1}) \quad \left(\frac{60}{16}\right)\text{sec} = 10 \text{ pulses}$$

(6) From Fig. 2.8(a) (Skolnik, Pg. 31), $nE_i(n) = I_1(10) = 7$

(7) T_e = effective noise temperature = $(F_n - 1)T_o$

where F_n = 10 db = 10 (numeric) and T_o = 290°K, the standard temperature. So

T_e = (10-1)290 = 2610°K.

(8) $k(T_a + T_e)B_{re} = 1.38 \times 10^{-23}(75 + 2610)10^6$

$$= 3.7 \quad 10^{-14} \text{ watts (long pulse)}$$

(9) $(S/N)_1$ = signal-to-noise ratio required at receiver output = 16 db = 39.8 (numeric) from Figure 2.7 (Skolnik, Pg. 28).

Using Eq. (1), we find that the maximum range is

$$R_{max\ell} = \frac{(2 \times 10^5 \text{ w})(1964)(0.449 \text{ w}^2)(1 \text{ w}^2)(7)}{(4\pi)^2(3.7 \times 10^{-14} \text{ w})40}$$

$\doteq$ 47.9 km for the long pulse, and

and

$$R_{maxs} = R_{max\ell}\left(\frac{B_{re}}{B_{rs}}\right)^{1/4} = 47.9(1/s)^{1/4} = 32.08 \text{ km}$$

for the short pulse

So, for $\sigma = 1 \text{ m}^2$ and $P_d = 0.95$,

$$R_{max} = 47.9 \text{ km (long pulse)}$$

$$R_{max} = 32.08 \text{ km (short pulse)}$$

Part b:

The maximum unambiguous range R_u is equal to

$$R_u = \frac{c}{2f_p} = \frac{3 \times 10^8}{2.650} = 230.77 \text{ km}$$

Part d:

For a $\sigma = 10 \text{ m}^2$ target, the detection range will be $10^{1/4} = 1.78$ times greater than that for a $\sigma = 1 \text{ m}^2$ target. So, the range at which an aircraft will be detected with $\sigma = 10 \text{ m}^2$, $P_d = 0.95$ will be

$$R = 1.78 \times R_{max} = 1.78 \times 47.96 = 85.36 \text{ km}$$

Part d:

The distance between radar and target along the line of sight is:

$$d_o = \sqrt{2h_1} + \sqrt{2h_2} \tag{2}$$

where:

h_1, h_2 = heights of radar antenna and target, respectively;

h = 50 ft;

d_o = 85.3 km = 52.9 miles.

So, from Eq. (1),

$$\sqrt{2 \times 50} + \sqrt{2h_2} = 52.9 \quad \text{or} \quad h_2 = 923.77 \text{ ft},$$

is the minimum altitude at which the radar can see the target.

Part e:

The single pulse power at the antenna output terminal is

$$P_r = \frac{P_t \, G_a \, \lambda^2 \, G_r}{(4\pi) \, R^2 \, (4\pi) \, L_p} \tag{3}$$

where:

(1) P_t = peak output power P_t = 200 kw

(2) G_a = antenna gain (calculated in part a)
= 32.9 db = 1964 (numeric)

(3) G_r = receiver antenna gain = 0 db = 1 (numeric)

(4) λ = wavelength = $c/f_o = \dfrac{3 \times 10^8}{5600 \times 10^6}$ = 0.0526 m

(5) R = range at which an aircraft will be detected with RCS = 10 m^2 (calculated in part c) = 85.3 km

(6) L_p = system losses = 3 db = 2 (numeric)

Using Eq. (3),

$$P_r = \frac{(2 \times 10^5 \text{ w})(1964)(0.0536)^2(1)}{(4\pi)^2 (83.5 \times 10^3 \text{m})^2 (2)} = -33.082 \text{ dbm}$$

Part f:

The camouflage factor c is

$$C = \frac{4}{(1 + \frac{1}{T_e B_{re}})^2} \times (\frac{f_p}{k})^{1/3} \qquad (4)$$

where k = 1640 or 400, T_e = Pulse width (long) = 1.3 μs

From Eq. (4), we get

$$C_1 = \frac{4}{1 + (\frac{1}{1.3 \times 10^{-6} \times 10^6})^2} \times (\frac{650}{1640})^{1/3} = 2.66 \text{ db}$$

$$C_2 = \frac{4}{1 + (\frac{1}{1.3 \times 10^{-6} \times 10^6})^2} \times (\frac{650}{400})^{1/3} = 4.7 \text{ db}$$

Part g:

The jammer output power P_j is equal to:

$$P_j = \frac{P_t G_a \sigma g^2 L_p C}{4\pi R_B^2 B_{re} C_j} \qquad (5)$$

where:

(1) P_t = peak output power = 2×10^5 watts;

(2) R_B = Burnthrough range inm = 18.5×10^3 m

(3) σ = target radar cross section = 10 m^2

(4) G_a = is the antenna gain = 1964 (numeric)

(5) L_p = system losses = 2 (numeric)

(6) C = J/s = 15 db = 31.6 (numeric)

(7) B_{re} = bandwidth for long pulse = 10^6 Hz

(8) B_r = Freq. the jammer transmits = 30×10^6 Hz

(9) C_j = gain of the jamming antenna

(10) g = propagation factor (Assume = 1)

From Eq. (5), we get

$$P_j = \frac{(2 \times 10^5\ \text{w})(1964)(10\ \text{m}^2)(2)(31.6)}{4\pi(18.5 \times 10^3\ \text{m})^2(1\ \text{MHz})(1)} = 5.77\ \text{w/MHz}$$

or P_j = .197 w/MHz for B_r = 30 MHz

B. PROBLEM #2: ARRAY BROADSIDE POWER GAIN

The AN/SPS-85 is a multifunction phased array radar used for search and track of missiles and satellites. The operating frequency f_o = 442 MHz and the transmit antenna is $d_1 \times d_2$ = 26.9×26.9 m rectangular array of N = 5184 elements. Assume that the illumination efficience of this array p_i = 0.65 and that the feed and phase shifter losses amount to p_R = 1.8 db for each element.

(a) Calculate the array broadside power gain

(b) Estimate the (pencil) beamwidth

(c) Calculate the spacing between elements assuming that they are uniformly spaced

(d) Calculate the directive gain of an element

(Hint: Assume uniform illumination when making this calculation and use the pattern multiplication theorem.)

Solution:

Part a:

The array broadside power gain G_p is equal to

$$G_p = \frac{4\pi A_e}{\lambda^2} \tag{6}$$

where λ = wavelength = $\frac{c}{f_o} = \frac{3 \times 10^8}{442 \times 10^6} = 0.678$ m

A_e = antenna effective area = $p_i p_R A$

where:

p_i = illumination efficiency of the array = 0.65;

p_R = phase shifter losses = $10^{-.18}$ = 0.66;

A = area of the antenna = $26.9 \times 26.9 = 723.6\ m^2$

So,

$$A_e = (0.65)(0.66)(723.6) = 310.4\ m^2$$

Using Eq. (6) with the above values we get

$$A_e = \frac{(4\pi)(310.4)}{(0.678)^2} = 8476.75 \text{ (numeric)} = 39.28 \text{ db}$$

Part b:

The beadmwidth is given by

$$\theta = [\frac{41250}{G_p/p_R}]^{1/2} = [\frac{41250}{\frac{8476.75}{0.66}}]^{1/2} \doteq 1.8°$$

Part c:

The spacing between elements, assuming that they are uniformly spaced is

$$d = \frac{d_1}{N^{1/2}} = \frac{26.9}{72} = 0.374 \text{ m} = 0.55\ \lambda$$

Part d:

The directive gain of the array is equal to:

$$G_{darray} = G_{delem} * G_{dgroup} \tag{7}$$

where:

$$G_{dgroup} = 5184;$$

$$G_{darray} = 12795$$

So

$$G_{dee} = \frac{G_{darray}}{G_{dgroup}} = \frac{12795}{5184} = 2.47 = 3.9 \text{ db}$$

C. PROBLEM #3: JAMMER'S REPEATER GAIN, JAMMER'S OUTPUT POWER

A conical scan radar missile seeker has the following parameters:

output power (peak)	P_t = 1 watt
Boresight antenna gain	G_a = 38 db
Antenna polarization	linear
Frequency	f_o = 93.7 GHz
RF losses	L_p = 3 db
Receiver noise bandwidth	B_n = 500 MHz
Receiver noise figure	F_n = 11 db
Pulse width	T = 50 ns
PRF	f_p = 100 kHz
integration time	T_i = 50 msec

The clear weather attenuation at this frequency A_t = 0.4 db/km and the sky temperature for cloudy conditions T_a = 270 degrees K. A repeater jammer is to be designed to protect a target with RCS = 14.8 dbsm.

(a) Calculate the maximum unambiguous range for this seeker

(b) The jammer uses circular polarized antennas with 10 degree pencil beam. Calculate the repeater gain required to realize a J/s of 10 db

(c) Calculate the jammer output power required at a range R = 1 km

(d) Assume that the seeker antenna has RF losses RFL = 1 db, an illumination efficiency r_i = 60%, a crossover loss L_{co} = 1 db and a pencilbeam pattern which is approximately Gaussian in shape. Calculate the diamter of the seeker dish antenna

(e) Calculate the squint angle

Solution:

Part a:

The maximum unambiguous range is equal to

$$R_u = \frac{c}{2f_p} = \frac{1.5 \times 10^5 \text{ kw/sec}}{10^5 \text{ Hz}} = 1.5 \text{ km}$$

Part b:

For the calculation of the gain of the repeater we have

$$S' = \frac{P_t G_a e^{-aR} \sigma}{4\pi R^2} \tag{8}$$

and

$$J' = \frac{P_t G_a e^{-aR}}{4\pi R^2} \frac{A_e G_e G_a}{L^2 p} \text{ watts} \tag{9}$$

Substituting Eq. (8) into Eq. (9), we get

$$\frac{S'}{J'} = \frac{A_e G_e G}{L^2 p \sigma}$$

or

$$G_e = \left(\frac{J'}{S'}\right) \frac{L_p^2 \sigma}{A_e G_a} \tag{10}$$

for 10° beam $\rightarrow$ $G = \frac{41250}{10^2} = 412.5 = 26.2$ db

$$A_e = \frac{\lambda^2}{4\pi} G = \frac{(3.2 \times 10^{-3} \text{ m})^2}{4\pi} 412.5 = 3.36 \times 10^{-4} \text{ m}^2$$

$$G_e = \frac{(10)(2)^2 (30.2 \text{ m}^2)}{(3.36 \times 10^{-4} \text{ m}^2)(412.5)} = 8716 \text{ or } 39.4 \text{ db}$$

Part c:

The jammer output power at a range R = 1 km is given as:

$$P_{out} = \frac{P_t \; G_a \; e^{-aR}}{4\pi R^2} \frac{A_e}{L_p} G_e \qquad (11)$$

where:

P_t = output power (peak) = 1w;

G_t = boresight antenna gain = 38 db $\doteq$ 6310;

$e^{-aR} = e^{-.4/10}$ = propagation attenuation;

A_e = effective antenna apertue;

G_e = Repeat gain anetnna;

L_p = RF losses = 3 db = 2 (numeric)

So, from Eq. (10) we get:

$$P_{out} = \frac{(1 \text{ w})(6310)(10^{-.4/10})(3.36 \times 10^{-4} \text{ m}^2)(8716)}{(4\pi)(10^3 \text{ m})^2(2)}$$

$$= 0.67 \text{ mw}$$

<u>Part d</u>:

The effective aperture of the antennat

$$A_e = p_R p_i A = \frac{\lambda^2}{4\pi} G = p_R p_i \frac{\pi D^2}{4} \rightarrow D = \frac{\lambda}{\pi}\sqrt{G/p_R p_i}$$

where:

$p_R = 10^{-1/10} = 0.794;$

$p_i = .6$

$G = G_t + 1 \text{ (db)} = 38 + 1 = 39 \text{ db} = 7943 \text{ (numeric)}$

So,

$$D = \frac{(3.2\ \text{mm})}{\pi} \sqrt{7943/(.794)(.6)} = 131\ \text{mm} = 13.1\ \text{cm}$$

Part e:

$$G = G_o\ e^{-2.776\ (\theta_q/\theta_B)^2}$$

$$-1\ \text{db crossover loss} \rightarrow \frac{G}{G_o} = .7943$$

$$.2.776(\theta_q/\theta_B)^2 = \ell n(\frac{G}{G_o})$$

$$\theta_q/\theta_B = .288$$

$$\theta_B = \sqrt{41253/G_d} = \sqrt{41253/10^4} = 2.03$$

So, the squint angle $\theta_q = (.288)(2.03) = .58$ degrees

D. PROBLEM #4: PULSE-COMPRESSION RADAR, NOISE JAMMING POWER

A shipboard pulse compression radar with a phased array antenna has the following parameters:

Array size	A = 3.65 m 3.65 m
Frequency	f_o = 3.3 GHz
Feed and phase shifter losses	L_{f_p} = 2.5 db/element
Sidelobe level	S.L. = 30 db below mainbeam
Illumination efficiency	p_i = 0.5
Polarization	linear
Output power	P_t = 4mw
2TW	TW = 1000

Weighting filter loss	L_w = 3 db
Integration (of compressed pulses)	coherent
Minimum output S/N for automatic detection	$(S/N)_{min}$ = 13 db

A raid of cruise missiles each having RCS = 3 dBsm have been launched at the ship. Two special purpose noise jamming ECN aircraft have been positioned at a range R = 100 km to provide screening. Each aircraft carrier C_r = 18 carcinotrons and is configured with circular polarized high gain, steerable jamming antennas, such that the ERP = 10 kw/tube. The bandwidth of the noise has been matched to the radar receiver bandwidth. Assume that the propagation factor g = 1.

(a) Calculate the effective area and power gain of the phased array

(b) Calculate the noise jamming power at the output of the phased array(receiver input). Assume that the jammers are in the radar antenna sidelobes

(c) Calculate the single pulse echo signal power at the output of the phased array assuming a cruise missile is illuminated at a range R_1 = 80 kw

(d) Calculate the single pulse J/S at the receiver input and at the receiver output

(e) Calculate the number of pulses that must be integrated to achieve burnthrough against a cruise missile at a range R_2 = 80 km. Assume the integration efficiency is 1

<u>Solution</u>:

The effective area of the phased array

$$A_e = p_i \, p_R A = (0.5)(10^{-.25})(3.65 \text{ m})^2 = 3.75 \text{ m}^2$$

where:

p_i = the illumination efficiency;

p_R = the phase shifter loss;

A = area of the array.

The power gain

$$G_p = \frac{4\pi A_e}{\lambda^2} = \frac{(4\pi)(3.75\ m^2)}{\left[\frac{3 \times 10^8}{3.3 \times 10^9}\right]^2} = 5696$$

Part b:

Noise jammer power is equal to:

$$P_j = \frac{P_t\ C_j\ A_e}{4\pi R^2\ L_m} \tag{12}$$

where:

P_j = the jammer power = 10^4 watts;

G_j = jammer gain = 2×18 = 36;

A_e = effective area of the array = 3.75 m^2

R = the range = 100 km = 10^5m

L_m = the losses = 3 db = 2 (numeric)

So

$$P_j = \frac{(2 \times 18 \times 10^4)(3.75 \times 10^{-3}\ m^2)}{(4\pi)(10^5\ m)^2(2)}$$

$$= 5.37 \times 10^{-9} \text{ watt or } -82.7 \text{ dbw or } -52.69 \text{ dbm}$$

Part c:

The single pulse echo signal power is

$$S = \frac{P_t G_p \sigma A_e}{(4\pi R_1^2)^2} \tag{13}$$

where:

P_t = output power = 4×10^6 watt;

G_p = power gain of the array 5696;

σ = RCS = 3 dbsm = 0.5 m^2;

R_1 = range of the cruise missile = 80 kw

So,

$$S = \frac{(4 \times 10^6 \text{ w})(5696)(0.5 \text{ m}^2)(3.75 \text{ m}^2)}{(4\pi)^2 (80 \times 10^3 \text{ m})^4}$$

$$= 6.61 \times 10^{-12} \text{ watt or } -111.8 \text{ dbw or } -81.8 \text{ dbm}$$

Part d:

The single pulse $(J/S)_{in}$ at the input of the receiver is

$$(J/S) = (-52.69 \text{ dbm}) - (-81.8 \text{ dbm}) = 29.2 \text{ db}$$

where:

J = jammer noise power = -52.69 dbm from part (b);

S = echo signal power = -81.8 dbm from part (c).

The single pulse S/J at the receiver output is

$$(S/J)_{out} = (S/J)_{in} + (2TW) - L_w = -29.2 \text{ db} + 30 \text{ db} - 3 \text{ db} = -2.2 \text{ db}$$

So,

$$(J/S)_{out} = +2.2 \text{ db}$$

Part e:

For perfect coherent integration we get

$$I_i(n) = n = (S/N)_{min} - (-S/J)_{out} = 13 + 2.2$$

$$= 15.2 \text{ db} \rightarrow n = 33 \text{ pulses}$$

E. PROBLEM #5: STAND OFF SPOT NOISE JAMMER

A mortar location radar has the following operating characteristics:

frequency	f_o = 16.1 GHz
peak power	P_t = 80 kw
antenna mainbeam gain	G_a = 46 db
antenna sidelobe gain	G_p = 16 db
PRF	f_p = 8600 MHz
pulse width	T = 0.25 μsec
receiver noise figure	F_n = 12 db
receiver noise bandwidth	B_n = 5 MHz
antenna noise temperature	T_a = 290 degrees K
antenna sector coverage	S_s = 25 degrees
antenna scan rate	S_r = 167 scan/sec
antenna polarization	linear
plumbing losses	L_p = 3 db

This radar is to be jammed by a standoff spot noise jammer. The jammer has the following characteristics:

Type	FM/noise
Power output	P_s = 100 w (cw)
PF noise bandwidth	B_{rf} = 20 MHz
Antenna gain	G_j = 23 db
Antenna polarization	circular

(a) Calculate the noise jamming power which can be ejected into this radar receiver through the radar antenna sidelobes from a range R = 20 km, in clear weather. Assume a line-of-sight path and neglect atmospheric absorption

(b) With the jammer positioned at R = 20 km as described above, the J/S = 24 db, when a certain mortar round passes through the radar beam at a range R_1 = 4 km. If the required camouflage factor is c = 0 db, at what range will these rounds burn through?

Solution:

The noise jamming power is given by the equation

$$J = \frac{P_j \; G_j \; B_n \; A_e}{4 \pi R^2 \; L_p} \tag{14}$$

where:

P_j = jammer output power = $\frac{100 \text{ w}}{20 \text{ MHz}}$ = 5 w/MHz

G_j = jammer antenna gain = 23 db = 200 (numeric)

B_n = receiver noise bandwidth = 5 MHz

A_e = effective antenna area = $G_p \lambda^2 / 4\pi$

where G_p = antenna sidelobe gains = 16 db or 40

λ = wavelength = $c/f_o = 3 \times 10^8 / 16.1 \times 10^9$

= 0.0186 w

So,

$$A_e = \frac{(0.0186\ w)^2}{4\pi}(40) = 1.1 \times 10^{-3}\ m^2$$

L_p = plumbing losses = 3 db or 2 (numeric)

R = range = 20 km = 20×10^3 m

Thus from (14)

$$J = \frac{(5\ w/MHz)(200)(5\ MHz)(1.1 \times 10^{-3}\ m^2)}{(4\pi)(20 \times 10^3\ m)^2(2)}$$

$$J = 0.549 \times 10^{-9} \text{ watts}$$

$$J = -92.6 \text{ dbm}$$

$$J = -62.6 \text{ dbm}$$

Part b:

J is constant for a standoff jammer while S varies as $1/R^4$. Therefore

$$(J/S) = \text{const } R^4$$

$$\frac{(J/S)_2}{(J/S)_1} = \left(\frac{R_2}{R_1}\right)^4 \rightarrow R_2 = R_1\left[\frac{(J/S)_2}{(J/S)_1}\right]^{1/4},$$

$$R_2 = 4\ kw\left[\frac{1}{2S_1}\right]^{1/4} = 1\ km$$

$(J/S)_1$ = noise jammer (1) = 1

$(J/S)_2$ = noise jammer (2) = 24 db or 251 (numeric)

F. PROBLEM #6: CHAFF, AVERAGE CROSS SECTION OF DIPOLES

Suppose that a chaff package is to be designed to produce a cloud cross-section with an average value of S_1 = 10 dbsm. Individual dipoles are Al F101 with cross sectional dimensions of 0.5×5 miles. For frequencies of 1, 2, 5 and 10 Ghz, make a table which shows the following information:

(a) The average cross-section of one dipole

(b) The number of dipoles required to achieve an average cloud cross-section of 10 dbsm

(c) The weight of material per square meter of RCS

Assume the dipoles are uncoupled.

Solution:

$$\lambda = \frac{3 \times 10^{10}}{f} \text{ cm/sec}$$

$$\bar{\sigma} = .5\,\lambda^2$$

$$N = \frac{\sigma_{avg}}{\bar{\sigma}}$$

$$V = (\tfrac{1}{2} \times 10^{-3} \text{ in})(5 \times 10^{-3} \text{ in})(2.54 \text{ cm/in})^2$$

$$V = (1.61 \times 10^{-6} \text{ cm}^2)\lambda$$

$$m = \rho_{AL} V,$$

$$\rho_{AL} = 2.7 \text{ gm/cm}^3$$

$$1 \text{ lb} = 454 \text{ gm}$$

f [GHz]	λ [cw]	$\bar{\sigma}$[cm^2]	N	V [cm^3]	w[grms]	$\frac{w}{\sigma_{avg}}$[gr/m^2]	$\frac{\#}{\sigma_{avg}}$[lb/m^2]
1	30	135	741	0.35	0.97	0.096	0.0002
2	15	33.75	2962.9	0.71	1.9	0.19	0.0004
5	6	5.4	18.5 K	1.8	4.8	0.48	0.0001
10	3	1.35	74.07 K	3.6	9.7	0.96	0.002

G. PROBLEM #7: SIGNAL-TO-CLUTTER RATIO, POWER SPECTRA DENSITY OF JAMMER

An MTI radar with a single delay line canceler has the following operating characteristics:

Peak power	P_t = 1 MW
Pulse width	T = 14 μs
PRF	f_p = 800 Hz
Antenna gain	G_a = 26 db
Frequency	f_o = 1 GHz
Receiver noise bandwidth	B_n = 1.5 MHz
Antenna scan rate	W_m = 10 RPM
Aziumth beamwidth	θ_B = 3.9 degrees
Receiver noise figure	F_n = 9.0 db
Antenna noise temperature	T_a = 100 degrees K
Plumbing losses	L_p = 2 db
Display	PPI (video int.)
False alarm probability	P_{fa} = 1E-12

(a) For the non-MTI mode, calculate the maximum range at which this radar can detect a non-fluctuating 0 dbsm target with a detection probability P_d = 0.9

(b) Suppose that this radar is operated in the MTI mode against a target aircraft with RCS = 10 dbsm immersed

in a chaff cloud with a cross section of 500 sq. meters. The target is 30 km from the radar and closing with radial velocity r = 300 knots. Assume that the power spectral density of the chaff return is as given in Skolnik, Figure 4.29. Calculate the target signal-to-clutter ratio at the output of the delay line canceler.

Solution:

Part a:

The maximum radar range may be written as

$$R_{max} = [\frac{P_t \ G_a \ A_e \ \sigma \ I_i(n)}{(4\pi)^2 \ k T_a + T_e) \ B_n \ (S/N)_1 \ L_s}]^{1/4}$$

where:

P_t = peak power = 10^6 W;

G_a = antenna gain = 26 db = 398 (numeric);

A_e = effective area

$$= \frac{\lambda^2 G_a}{4\pi} = (\frac{c}{f_u})^2 \frac{G_a}{4\pi} = (\frac{3 \times 10^9}{10^9})^2 \frac{(398)}{4\pi} = 2.85 \ m^2$$

σ = radar cross section = 1 m^2

kT_e = $(F_n-1)T_o$ = (7.94-1)290 = 2013.55

$$k(T_a+T_e)B_n = 1.38 \times 10^{-23}(100+2013.55)1.5 \times 10^6$$

$$= 43.7 \times 10^{-15} \ w$$

$(S/N)_1$ = signal-to-noise ratio (from Figure 2.7 (Skolnik, Pg. 28))

= 15.8 db = 38(for P_{fa} = 1E-12 and P_d = 0.9)

$$\bar{n} = \text{pulses integrated} = f_p \frac{\theta_B}{w_m}$$

$$= (800\ \text{sec}^{-1})(3.9°)/(360°/6\ \text{sec}) = 52\ \text{pulses}$$

$$I_1(52) \doteq 23.5 = 13.7\ \text{db}\ \text{(Figure 2.8 a/b (Skolnik, Pg. 31))}$$

Thus,

$$R_{max} = \left[\frac{(10^6\ w)(398)(2.85\ m^2)(1\ m^2)(23.5)}{(4\pi)^2(43.7 \times 10^{-15}\ w)(38)(1.58)}\right]^{1/4}$$

$$R_{max} = 89.46\ \text{km}$$

Part b:

Since the target and chaff cloud are only 30 km from the radar the returns will be well above the thermal noise level and the receiver will be clutter dominated.

$$\frac{S_{avg}}{C_{out}} = \frac{|H(f_d)|^2 S_{in}}{C_{in}/CA} = |H(f_d)|^2 CA(S/C)_{in}.$$

$$f_d(\text{Hz}) = \frac{1.03\ U_r}{\lambda} = \frac{1.03(300\ \text{knots})}{0.3\ m}\ \text{(Skolnik, Eq. 3.26)}$$

$$f_d = 1030\ \text{Hz}$$

$$|H(f_d)|^2 = |2\sin(\pi f_d T_p)|^2 = 4\sin^2[\pi(1030/800)]$$

$$= 2.47$$

$$CA = \frac{.5}{1 - e^{-2\pi^2 T_p^2 \sigma_c^2}} \doteq \frac{af_p^2}{2\pi^2 f_o^2}\ (G_c << f_p)$$

(Eq. 4.23 and 4.24 from Skolnik, Pg. 132-133)

From Figure 4.29 (Skolnik) for chaff $a = 10^{16}$ and

$$\sigma_c^2 = \frac{f_o^2}{2a} = 50 \quad \text{so} \quad CA = \frac{(10^{16})(800)^2}{2\pi^2(10^9)^2} = 324 = 25.1 \text{ db}$$

$$(S/C)_{in} = \sigma_{tH}/\sigma_{chaff} = 10/500 = 1/50 = -17 \text{ db}$$

So,

$$(S/C)_{out} = (1/50)(2.47)(324) = 16 = 12 \text{ db}$$

H. PROBLEM #8: WEIGHTING FILTERS

An airborne periscope detecting radar has the following characteristics:

Frequency	f_o = 9.510 GHz (linear chirp)
Peak power	P_t = 500 kw
PRF	f_p = 1500 Hz
Pulse width	T = 500 nanoseconds
Weighting filter	Hamming
Antenna gain	G_a = 35 db
Polarization	Vertical
Azimuth beamwidth	θ_B = 2.4 degrees
Antenna scan rate	w_m = 300 RPM
Plumbing lcsses	L_p = 5 db
R_x noise figure	R_x = 7.5 db

An ASW aircraft with this radar encounters a submarine with periscope exposed under the following conditions:

Aircraft altitude	H_a = 2000 ft
Range to submarine	R_s = 16 kyards
Periscope RCS	RCS = 1 m^2

(a) Assume that the sea clutter spikes resolved by this high resolution radar have an average duration t_{fa} = 2 sec and that the sea state 2-3 statistics shown in [Ref. 1, Figure 13.5] apply. How many db above the median clutter level must a threshold be set to achieve a 100 seconds false alarm time when the receiver is clutter dominated?

(b) Calculate the single pulse signal-clutter power ratio at the radar receiver input

(c) At the output of the weighting filter calculate the 3 db width of the compressed pulse and the peak signal-mean clutter power ratio

(d) Assume that a 5 second scan-scan post detection integration period is employed to separate targets (which remain) from clutter spikes (which go away). Calculate the integration improvement

Solution:

Part a:

For the clutter waveform

$$P_{fa} = \frac{t_{fa}}{T_{fa}} = \frac{2\text{ sec}}{100\text{ sec}} = 0.02$$

Using Figure 13.5 (Skolnik) for P_{fa} = 0.02, σ_c/σ_{cmed} = 12.5 db threshold must be set 12.5 db above the median clutter power level.

Part b:

From Eq. 13.6 (Skolnik, Pg. 472), the signal power S returned from a target with cross section σ is

$$S = \frac{P_t G_a \sigma A_e}{(4\pi)^2 R^4 L_p}$$

where:

AD-A164 143 INTRODUCTION TO THE MICROCOMPUTERS FOR SOLVING RADAR AND ELECTRONIC WARFARE PROBLEMS(U) NAVAL POSTGRADUATE SCHOOL MONTEREY CA C D VERGOS DEC 85 2/3

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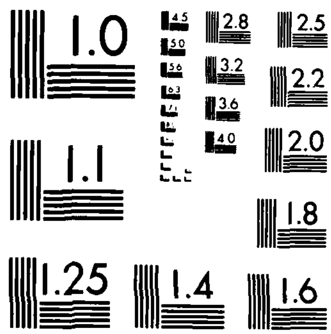


MICROCOPY RESOLUTION TEST CHART

DARDS-1963-A

$$P_t = 500 \times 10^3 \text{ w} = 87 \text{ dbm}$$

$$G_a = 35 \text{ db} = 3162 \text{ (numeric)}$$

$$\sigma = 1 \text{ w}^2 = 0 \text{ db}$$

$$A_e = (\lambda^2/4\pi) G_a = \frac{(0.03)^2}{4\pi} 3162 = .227 \text{ m}^2 = -6.4 \text{ dbm}$$

$$4\pi = 11 \text{ db}$$

$$R = 16 \times 10^3 = 9.09 \text{ mi} = 14.64 \text{ km} = 41.65 \text{ dbm}$$

$$L_p = 5 \text{ db}$$

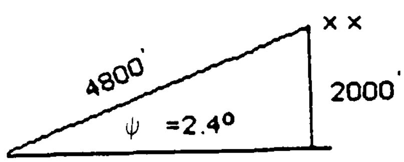
$$S = [87 \text{ dbm} + 35 - 6.470] - [11 \times 2 + 41.65*4 + 5]$$

$$= -78 \text{ dbm}$$

The echo from surface clutter is

$$C = \frac{P_t \; G_a \; A_e \; \sigma_o \; \theta_B \; (CT/2)\sec(\psi)}{(4\pi)^2 \; R^3 \; (L_p/2)}$$ (Eq. 13.5 from Skolnik, Pg. 472)

Part b:



ψ = grazing angle

$$\theta_B = 2.4° = .042 \text{ rad} = -13.8 \text{ dbrad}$$

$$CT/2 = (1.5 \times 10^8 \text{ m/s})(0.5 \times 10^{-6} \text{ sec})$$

$$\sec \psi = 1/\cos \psi \doteq 1 \quad (\psi = 2.4°)$$

From Figure 13.3 (Skolnik, Pg. 475), $\sigma_o = -32$ db

Thus

$$C = [87 \text{ dbm} + 35 - 6.4 - 32 - 13.8 + 18.6 + 0]$$

$$- [11 \times 2 + 41.65 \times 3 + 2.5] = -61.1 \text{ dbm}$$

So,

$$(S/C)_{in} = (-78 \text{ dbm}) - (-61.1 \text{ dbm}) = -16.9 \text{ db}$$

Part c:

For the Hamming filter [Ref. 1], the peak sidelobe S_{LL} = -42.8 db, the loss = 1.34 and the relative mainlobd width = 1.5. So the width of the compressed pulse at the output of the weighting filter is

$$T_c = \frac{T}{TW} \times 1.5 = \frac{(500 \times 10^{-9} \text{ sec})(1.5)}{(500 \times 10^{-9} \text{ sec})(0.5 \times 10^{9} \text{ Hz})}$$

$$= 3 \times 10^{-9} \text{ sec}$$

The improvement in S/C is

$$10 \log_{10}(2 \text{ TW}) - 1.34 \text{ db} = 25.7 \text{ db}$$

so

$$(S/C)_{out} = (-16.9 \text{ db}) + (25.7 \text{ db}) \doteq 8 \text{ db}$$

Part d:

$$\# \text{ hits/scan} = \frac{\theta_B f_p}{6 \, w_n} = \frac{2.4° \text{ v } 1500}{6 \text{ v } 300} = 2$$

$$\# \text{ hits} = (2 \frac{\text{hits}}{\text{scan}}) \text{ v } (\frac{300}{60}) \text{ v } (5 \text{ sec}) = 50 \text{ hits}$$

From Figure 2.80 (Skolnik, Pg. 31) $I_i(5) = 25.118 = 14$ db with integration (S/C) = 14 db + 8 db = 22 db.

I. PROBLEM #9: MTI FILTERS, CHAFF DIPOLES

An MTI radar has the following characteristics:

Frequency	$f_o = 1.3$ GHz
Peak power	$P_t = 2$ mw
Antenna gain	$G_a = 35$ db
Azimuth beamwidth	$\theta_B = 1.3$ degrees
Elevation coverage	0.2-45 degrees
Antenna scan rate	$w_n = 5$ RPM
PRF	$f_p = 360$ Hz
Pulse width	$T = 6$ μsec
Receiver noise figure	$F_n = 8$ db

Assume that this radar has a 2 pulse canceler. An aircraft with RCS = 10 dbsm at a range of 100 km is to be protected with a chaff corridor. Assume that the chaff return has Gaussian power spectral density with RMS velocity spread 1.0 m/s. Calculate the number of half wave chaff dipoles per resolution cell required to produce a minimum clutter-target signal ratio of 10 db at the output of the MTI filter.

<u>Solution</u>:

The best improvement the delay line canceler will provide is

$$\frac{(S/C)_{out}}{(S/C)_{in}} = \frac{C_{in}}{C_{out}} \times \frac{S_{out}}{S_{in}} = CA|H(f)|^2 = \frac{f_p^2 \lambda^2}{16\pi^2 \sigma_u^2} 4$$

$$= \frac{(360 \text{ Hz})^2 (.231 \text{ w})^2}{4\pi^2 (1 \text{ w/sec})^2}$$

$$I_{max} = 175 = 22.4 \text{ db}$$

With the target at 100 km, the receiver will be clutter dominated. We require

$$(S/C)_{in} = -10 \text{ db} - 22.4 \text{ db} = \frac{1}{1750}$$

or

$$\frac{\sigma_t}{N\bar{\sigma}} = \frac{\sigma_t}{N(0.15\lambda^2)} = (S/C)_{in}$$

$$N = \frac{10}{(0.15 \times .231^2 w^2)(1/1750)} = 2.19 \times 10^6 \text{ dipoles}$$

(in resolution cell)

J. PROBLEM #10: MINIMUM DETECTABLE SIGNAL

An HF compressive receive is to be designed to sweep the 2-32 MHz band 25 times per second and to provide a frequency resolution of 2 Khz.

(a) Calculate the bandwidth and time delay required of the compressive filter for this receiver

(b) Calculate the MDS of this receiver, assuming a receiver noise figure of 3 db and an antenna noise temperature of 290°K

Solution:

Part a:

$$\frac{W}{T} = \frac{32-2}{1/25 \text{ sec}} = \frac{30 \text{ MHz}}{1/25 \text{ sec}} = 750 \text{ MHz/sec}$$

$$T1 = \frac{1}{\Delta f} = \frac{1}{2 \cdot 10^3 \text{ Hz}} = .5 \times 10^{-3} \text{ sec} \quad \text{(time delay)}$$

$$W = \left(\frac{W1}{T}\right) \times T = 750 \times (0.5 \times 10^{-3}) = 375 \text{ kHz (bandwidth)}$$

Part b:

$$T_e = (F-1)290) = (1.99-1)290 = 288.626 \text{ K}$$

$$NDS = k(T_a + T_e)B_n \frac{1}{2Tw} \quad \text{but } B_n = w \text{ so}$$

$$NDS = k(T_a + T_e)\frac{1}{2T} = -170.9 + 3 + 30 \text{ dbm} = -138 \text{ dbm}$$

V. CONCLUSION

The programs were written for solving problems of radar and Electronic Warfare. They are in easy-to-understand Basic language. They were written in the interactive method. As a result these programs are "user friendly." They were very time consuming to write in this mode. The interactive method is very amenable to work with and should be helpful to the Naval officer, in the field of radar and electronic warfare. Using the same problems but with parameters of other systems, one can understand the performance of different types of radar and jammers.

Many subroutines and interation loops are used so that even one who has little experience in programming can read and easily comprehend the programs and can expand or modify them according to his needs.

The author hopes that these programs will be an assistance to students, and Naval officers involved in radar and electronic warfare.

The programming language is Microsoft Basic so that anyone can work on these programs on any IBM or IBM-compatible computer as well as Apple microcomputers without requiring any modifications in these programs.

These programs may be used on boardship to aid in the technical aspects of a tactical operation. They may be used by the Naval officer in program management in radar and

electronic warfare systems or in evaluation and design at a Naval laboratory. On board ship as a combat information center officer or Electronic Warfare officer these problems addressed arise inumerable times. As an example, your ship is in the Indian Ocean and there is a threat of an antiship cruise missile whose radar parameters you are aware of (i.e., Harpoon, Automat, or Exocet) and it is your responsibility to provide shipboard defense. If per chance you have worked with these problems and you are familiar with characteristics of your defense systems, the more viable ECM action can be made. For instance, you are aware of your ships radar cross section as a function of aspect angle relative to the missile threat. You are aware of the radar cross section of your chaff loads and you are aware of the power outputs and characteristics of your decoys. Using the enclosed programs and the variations of the parameters associated with them should allow you to obtain a better understanding of what actions you should take for ships defense. It is only through the working of many problems of these types in many different tactical scenarios that a proper technical expertise in radar and EW can be obtained.

Lastly, the author believes that this group of problems were selected to include a variety of timely and useful situations that one may encounter in the radar and electronic warfare field.

APPENDIX A

A listing of the radar computer programs is provided and an output of the results for each one of these programs is also included.

```
10  PRINT : PRINT TAB(30); " PROBLEM #1"
20  PRINT TAB(30); " ----------"
30  LPRINT : LPRINT TAB(30); " PROBLEM #1"
40  LPRINT TAB(30); " ----------"
50  PRINT : PRINT "ENTER THE BANDWIDTH OF THE AMPLIFIER WITHOUT UNITS :  B=?"
60   INPUT B
70  PRINT : PRINT  "WHAT ARE THE UNITS OF THE BANDWIDTH?"
80   PRINT  "1.  HZ "
90   PRINT  "2. KHZ"
100 PRINT  "3. MHZ"
110 PRINT  "4. GHZ"
120 INPUT A$      'input selection
130 IF A$ = "1" THEN B=B
140 IF A$ = "2" THEN B=B*1000
150 IF A$ = "3" THEN B=B*1000000!
160 IF A$ = "4" THEN B=B*1000000000#
170 PRINT : PRINT " ENTER THE FALSE ALARM TIME WITHOUT UNITS : T=?"
180 INPUT T
190 PRINT : PRINT " WHAT ARE THE UNITS OF THE FALSE ALARM TIME?"
200 PRINT "1. seconds"
210 PRINT "2. minutes"
220 PRINT "3. hours"
230 INPUT B$  'input selection
240 IF B$="1" THEN T=T
250 IF B$="2" THEN T=T*60
260 IF B$="3" THEN T=T*3600
270 REM : calculation of the threshold -to-rms ratio
280 LET X=SQR(2*LOG(B*T)) ' numeric value
290 LET M=.4342945#
300 LET X1= 10*M*LOG(X) ' db value
310 IF A$="1" THEN LPRINT : LPRINT " THE BANDWIDTH B=";B;"HZ"
320 IF A$="2" THEN B=B/1000 : LPRINT : LPRINT " THE BANDWIDTH B=";B;"KHZ"
330 IF A$="3" THEN B=B/1000000! : LPRINT : LPRINT  " THE BANDWIDTH B=";B;"MHZ"
340 IF A$="4" THEN B=B/1000000000# : LPRINT : LPRINT " THE BANDWIDTH B=";B;"GHZ"
350 IF B$="1" THEN LPRINT : LPRINT  " THE FALSE ALARM TIME T=";T;"sec"
```

```
360 IF B$="2" THEN T=T/60 :LPRINT :LPRINT "THE FALSE ALARM TIME T=";T;"min"
370 IF B$="3" THEN T=T/3600 : LPRINT : LPRINT "THE FALSE ALARM TIME T=";T;"Hrs"
380 PRINT : PRINT "THE THRESHOLD-TO-RMS NOISE VOLTAGE
 V/SQR(YO)=";X;"(numeric)";"or";X1;"(db)"
390 LPRINT :LPRINT "THE THRESHOLD-TO-RMS NOISE VOLTAGE
 V/SQR(YO)=";X;"(numeric)";"or";X1;"(db)"
400 PRINT : PRINT "DO YOY WANT TO USE THIS PROGRAM FOR DIFFERENT OR THE SAME DATA
 Y/N?"
410 INPUT C$
420 IF LEFT$(C$,1)="Y" OR LEFT$(C$,1)="y"  THEN 40
430 END
```

PROBLEM#1

THE BANDWIDTH B= 4MHZ

THE FALSE ALARM TIME T= 5 min

THE THRESHOLD-TO-RMS NOISE VOLTAGE V/SQR(YO)= 6.466156 (numeric) or 8.106462 (db)

THE BANDWIDTH B= 4MHZ

THE FALSE ALARM TIME T= 50 min

THE THRESHOLD-TO-RMS NOISE VOLTAGE V/SQR(YO)= 6.812954 (numeric) or 8.333355 (db)

THE BANDWIDTH B= 4MHZ

THE FALSE ALARM TIME T= 500 min

THE THRESHOLD-TO-RMS NOISE VOLTAGE V/SQR(YO)= 7.142935 (numeric) or 8.538767 (db)

```
10  PRINT : PRINT TAB(30); " PROBLEM #2 "
20  PRINT TAB(30); " ----------"
30  LPRINT : LPRINT TAB(30); " PROBLEM #2 "
40  LPRINT TAB(30); " ----------"
50  PRINT : PRINT " ENTER THE NUMBER OF THE m NOISE PULSES "
60  INPUT A     '# OF m NOISE PULSES
70  PRINT : PRINT " 1. m="A
80  LPRINT : LPRINT " 1. m="A
90  PRINT : PRINT " ENTER THE NUMBER OF THE n SIGNAL-PLUS-NOISE PULSES"
100 INPUT B     '# OF n SIGNAL-PLUS-NOISE PULSES
110 PRINT : PRINT " 2. n="B
120 LPRINT : LPRINT " 2. n="B
130 PRINT : PRINT " FROM Fig. 2.8 (b) (SKOLNIK Pg 31) YOU CAN FIND THE INTEGRATION LOSS
 FOR Li(m+n) AND Li(n), SINCE YOU KNOW Pd,m,n, WHICH ARE GIVEN IN THE PROBLEM"
140 LET C=A+B
150 PRINT : PRINT " ENTER THE VALUE OF THE Li("C")"
160 INPUT D   'THIS IS THE VALUE OF Li(m+n) IN db"
170 PRINT : PRINT " 3. THE INTEGRATION LOSS FOR Li("C")""="D;"db"
180 LPRINT :LPRINT " 3. THE INTEGRATION LOSS FOR Li("C")""="D;"db"
190 PRINT : PRINT " ENTER THE VALUE OF THE Li("B")"
200 INPUT E   'THIS IS THE VALUE OF Li(n) IN db"
210 PRINT : PRINT " 4. THE INTEGRATION LOSS FOR Li("B")""="E"db"
220 LPRINT :LPRINT " 4. THE INTEGRATION LOSS FOR Li("B")""="E"db"
230'*************************************
240 REM : CALCULATION OF THE COLLAPSING LOSS
251'*************************************
260 LET F=D-E : F1=F/10 : F1=10^F1  ' CONVERTION FROM "db" TO "NUMERIC"
270 PRINT : PRINT " 5. THE COLLAPSING LOSS Li("A","B")""="F1;"NUMERIC";" OR";F;"db"
280 LPRINT :LPRINT " 5. THE COLLAPSING LOSS Li("A","B")""="F1;"NUMERIC";" OR";F;"db"
290 PRINT : PRINT " DO YOU WANT TO TRY AGAIN FOR DIFFERENT OR THE SAME DATA Y/N?"
300 INPUT G$   'INPUT SELECTION
310 IF LEFT$(G$,1)="Y" OR LEFT$(G$,1)="y" THEN LPRINT : LPRINT : LPRINT TAB(15);"
 ****************************************":GOTO50
320 END
```

PROBLEM#2

1. m= 10

2. n= 10

3. THE INTEGRATION LOSS FOR L1(20)= 1.9 db

4. THE INTEGRATION LOSS FOR L1(10)= 1.3 db

5. THE COLLAPSING LOSS L1(10,10)= 1.148154 NUMERIC OR .6 db

****

1. m= 90

2. n= 10

3. THE INTEGRATION LOSS FOR L1(100)= 4.1 db

4. THE INTEGRATION LOSS FOR L1(10)= 1.3 db

5. THE COLLAPSING LOSS L1(90,10)= 1.905461 NUMERIC OR 2.8 db

```
10    REM :        **** MAIN PROGRAM ****
20    PRINT : PRINT TAB(30); " *** PROBLEM #3 ***"
30    LPRINT : LPRINT TAB(30); " *** PROBLEM #3 ***"
40    GOSUB 90    : GOSUB 430
50    GOSUB 780   : GOSUB 840
60    GOSUB 930   : GOSUB 1180
70    GOTO 1360
80    REM *************************************************
90    REM       SUBPROGRAM THAT INPUTS THE DATA
100   REM *************************************************
110   PRINT : PRINT " ENTER THE MAGNETRONS PEAK POWER Pt IN MEGAWATTS"
120   INPUT Pt
130   PRINT : PRINT " ENTER THE PULSE WIDTH Tw IN MICROSEC"
140   INPUT Tw
150   PRINT : PRINT " ENTER THE PULSE REPETITION FREQUENCY fp IN HZ"
160   INPUT fp
170   PRINT : PRINT " ENTER THE OPERATION WAVELENGTH IN CENTEMETERS"
180   INPUT l
190   PRINT : PRINT " ENTER THE EFFECTIVE ANTENNA APERTURE Ae IN SQUARE METERS"
200   INPUT Ae
210   PRINT : PRINT " ENTER THE #OF HITS INTEGRATED n"
220   INPUT n
230   PRINT : PRINT " ENTER THE NOISE BANDWIDTH IN MEGAHERTZ"
240   INPUT Bn
250   PRINT : PRINT " ENTER THE RECEIVER NOISE FIGURE Ff IN db"
260   INPUT Ff
270   PRINT : PRINT " ENTER THE PLUMBING LOSSES Lp1 IN db"
280   INPUT Lp1
290   PRINT : PRINT " ENTER THE BEAM SHAPE Lbs IN db"
300   INPUT Lbs
310   PRINT : PRINT " ENTER THE FACTOR BY WHICH THE INTEGRATION EFFICIENCY IS REDUCED"
320   INPUT a
330   PRINT : PRINT " ENTER THE FALSE ALARM PROBABILITY Pf"
340   INPUT Pf
350   PRINT : PRINT " ENTER THE PROBABILITY OF DETECTION Pd"
```

```
360  INPUT Pd
370  PRINT : PRINT " ENTER THE TARGET AVERAGE CROSS SECTION Sav IN SQUARE METERS"
380  INPUT Sav
390  PRINT : PRINT " ENTER THE CASE THAT YOU ARE : CASE1,CASE2...?"
400  INPUT A$
410  RETURN
420  REM ************************************
430  REM SUBROGRAM THAT PRINTS THE INPUT DATA
440  REM ************************************
450  LPRINT: LPRINT "G I V E N" : LPRINT "---------"
460  PRINT : PRINT "1. Pt=";Pt;"MW" SPC(17); " : MAGNETRON'S PEAK POWER"
470  LPRINT : LPRINT "1. Pt=";Pt;"MW" SPC(17); " : MAGNETRON'S PEAK POWER"
480  PRINT : PRINT "21 Tw=";Tw;"MICSEC" SPC(13); " : PULSE WIDTH "
490  LPRINT : LPRINT "21 Tw=";Tw;"MICSEC" SPC(13); " :PULSE WIDTH "
500  PRINT: PRINT "3. fp=";fp;"HZ" SPC(15); " : PULSE REPETITION FREQUENCY "
510  LPRINT : LPRINT "3. fp=";fp;"HZ" SPC(15); " : PULSE REPETITION FREQUENCY "
520  PRINT : PRINT "4. l=";l;"centimeters" SPC(8); " : OPERATION WAVELENGTH "
530  LPRINT : LPRINT "4. l=";l;"centimeters" SPC(8); " : OPERATION WAVELENGTH "
540  PRINT : PRINT "5. Ae=";Ae;"square meters" SPC(4); " : EFFECTIVE ANTENNA APERTURE "
550  LPRINT : LPRINT "5. Ae=";Ae;"square meters" SPC(4); " : EFFECTIVE ANTENNA APERTURE "
560  PRINT : PRINT "6. n=";n SPC(19); " : #OF HITS INTEGRATED "
570  LPRINT : LPRINT "6. n=";n SPC(19); " : #OF HITS INTEGRATED "
580  PRINT :PRINT "7. Bn=";Bn;"MHZ" SPC(16); " : NOISE BANDWIDTH"
590  LPRINT : LPRINT "7. Bn=";Bn;"MHZ" SPC(16); " : NOISE BANDWIDTH"
600  PRINT : PRINT "8. Ff=";Ff;"db" SPC(16); " : RECEIVER NOISE FIGURE"
610  LPRINT : LPRINT "8. Ff=";Ff;"db" SPC(16); " : RECEIVER NOISE FIGURE"
620  PRINT : PRINT "9. Lp1=";Lp1;"db" SPC(16); " : PLUMBING LOSSES"
630  LPRINT : LPRINT "9. Lp1=";Lp1;"db" SPC(16); " : PLUMBING LOSSES"
640  PRINT :PRINT "10. Lbs=";Lbs;"db" SPC(15); " : BEAM SHAPE"
650  LPRINT :LPRINT "10. Lbs=";Lbs;"db" SPC(15); " : BEAM SHAPE"
660  PRINT : PRINT "11. e=";e SPC(17); " : FACTOR BY WHICH INTEGRATION EFF. IS REDUCED"
670  LPRINT : LPRINT "11. e=";e SPC(17); " : FACTOR BY WHICH INTEGRATION EFF. IS REDUCED"
680  PRINT: PRINT "12. Pf=";Pf SPC(14); " : FALSE ALARM PROBABILITY"
690  LPRINT : LPRINT "12. Pf=";Pf SPC(14); " : FALSE ALARM PROBABILITY"
700  PRINT : PRINT "13. Pd=";Pd SPC(16); "  PROBABILITY OF DETECTION"
```

```
710  LPRINT : LPRINT "13. Pd=";Pd SPC(16) " : PROBABILITY OF DETECTION"
720  PRINT : PRINT "14. Sav=";Sav;"sq.meters"SPC(8);" : TARGET AVERAGE CROSS SECTION"
730  LPRINT : LPRINT "14. Sav=";Sav;"sq.meters" SPC(8) " : TARGET AVERAGE CROSS SECTION"
740  PRINT : PRINT "15. YOU 'RE CASE IS" SPC(10);A$
750  LPRINT : LPRINT "15. YOU 'RE CASE IS" SPC(10);A$
760  RETURN
770  REM:*******************************************
780  REM:  SUBR. THAT CALCULATES THE MAX. UNAB. RANGE
790  REM:*******************************************
800  LET C=3*10^8              'm/s
810  LET Runab=C/(2*fp)
820  RETURN
830  REM:*******************************************
840  REM:  SUBR. THAT PRINTS THE OUTPUT FOR PART a
850  REM:*******************************************
860  PRINT : PRINT "PART a:"
870  LPRINT : LPRINT "PART a:"
880  LPRINT "-------"
890  PRINT : PRINT " 1(a). Runab=";Runab/1000;"KM", " : THE MAX. UNAB. RANGE"
900  LPRINT : LPRINT " 1(a). Runab=";Runab/1000;"KM", " : THE MAX. UNAB. RANGE"
910  RETURN
920  REM:*******************************************
930  REM:  SUBR. THAT CALCULATES THE MAX. RANGE
940  REM:*******************************************
950  LET Bn=Bn*10^6              'CONVERTION FROM MHZ TO HZ
960  LET Pt=Pt*10^6              'CONVERTION FROM Mw TO w
970  LET K=1.38*(10^(-23))       'BOLTZMAN'S CONSTANT IN j/deg.
980  LET T0=290                  'STANDARD TEMPERATURE IN KELVIN
990  LET PI=3.14159
1000 LET Ff=Ff/10 : Ff1=10^Ff    'CONVERTION FROM db TO NUMERIC
1010 LET Ls=Lp1+Lbs              'SYSTEM LOSSES IN db
1020 LET Ls1=Ls/10 : Ls2=10^Ls1  'CONVERTION FROM db TO NUMERIC
1030 LET l=l/100                 'CONVERTION FROM cm TO m
1040 PRINT : PRINT " FROM FIg. 2.7 (SKOLNIK Pg. 28) YOU CAN FIND THE (S/N)1 SINCE YOU KNOW
 Pd AND Pf"
```

```
1050 PRINT : PRINT " ENTER THE VALUE OF THE (S/N)1 IN db"
1060 INPUT A1
1070 PRINT : PRINT "SINCE YOU ARE IN CASE2 FROM Fig. 2.23 (SKOLNIK Pg. 48) YOU CAN FIND
THEADDITIONAL(S/N)1ad"
1080 PRINT : PRINT " ENTER THE VALUE OF THE (S/N)1ad"
1090 INPUT A2
1100 LET A=A1+A2 : A3=A/10 : A4=10^A3     THIS IS THE VALUE OF THE (S/N)1tot IN db AND
INNUMERIC
1110 PRINT :PRINT " SINCE YUO KNOW THE #OF HITS INTEGRATED (NONCOHERENT) FROM Fig.
2.24(SKOLNIK Pg. 49) YOU CAN FIND THE INTEGRATION IMR.FACTOR I1"
1120 PRINT : PRINT " ENTERTHE VALUE OF THE INTEGRATION IMR. FACTOR"
1130 INPUT I1
1140 LET I11=I1/10 : I12=10^I11
1150LETRmax=SQR(SQR((Pt*(Ae^2)*Sav*I12*.85)/(4*PI*K*T0*Ff1*Bn*(1^2)*A4*Ls2)))
1160 RETURN
1170 REM:**************************************
1180 REM:  SUBR. THAT PRINTS THE OUTPUT FOR PART b
1190 REM:**************************************
1200 PRINT : PRINT : PRINT  " PART b:"
1210 LPRINT : LPRINT : LPRINT " PART b:"
1220 LPRINT " -------"
1230 PRINT : PRINT " 2(a). Ls=";Ls;"db", " : TOTAL SYSTEM LOSSES"
1240 LPRINT : LPRINT " 2(a). Ls=";Ls;"db", " : TOTAL SYSTEM LOSSES"
1250 PRINT : PRINT " 2(b). (S/N)1=";A1;"db", " : SIGNAL-TO-NOISE RATIO"
1260 LPRINT : LPRINT " 2(b). (S/N)1=";A1;"db", " : SIGNAL-TO-NOISE RATIO"
1270 PRINT : PRINT " 2(c). (S/N)1ad=";A2;"db", " : ADDITIONAL SIGNAL-TO-NOISE RATIO"
1280 LPRINT : LPRINT " 2(c). (S/N)1ad=";A2;"db", " : ADDITIONAL SIGNAL-TO-NOISE RATIO"
1290 PRINT : PRINT " 2(d). (S/N)tot=";A;"db", " : TOTAL SIGNAL-TO-NOISE RATIO"
1300 LPRINT : PRINT " 2(d). (S/N)tot=";A;"db", " : TOTAL SIGNAL-TO-NOISE RATIO"
1310 PRINT : PRINT " 2(e). I1(n)=";I1;"db", " : INTEGRATION IMR. FACTOR"
1320 LPRINT : LPRINT " 2(e). I1(n)=";I1;"db", " : INTEGRATION IMR. FACTOR"
1330 PRINT : PRINT " 2(f). Rmax=";Rmax/1000;"KM", " : MAXIMUM RANGE"
1340 LPRINT : LPRINT " 2(f). Rmax=";Rmax/1000;"KM", " : MAXIMUM RANGE"
1350 RETURN
1360 PRINT : PRINT " DO YOU WANT TO TRY FOR DIFFERENT OR THE SAME DATA Y/N?"
```

```
1370  INPUT C$
1380  IF LEFT$(C$,1)="Y" OR LEFT$(C$,1)="y"  THEN 40
1390  END
```

*** PROBLEM #3 ***

GIVEN

1. Pt= 1 MW	: MAGNETRON'S PEAK POWER
2. Tw= 1 MICSEC	: PULSE WIDTH
3. fp= 250 HZ	: PULSE REPETITION FREQUENCY
4. l= 10 centimeters	: OPERATION WAVELENGTH
5. Ae= 200 square meters	: EFFECTIVE ANTENNA APERTURE
6. n= 10	: #OF HITS INTEGRATED
7. Bn= 1 MHZ	: NOISE BANDWIDTH
8. Ff= 10 db	: RECEIVER NOISE FIGURE
9. Lp1= 3 db	: PLUMBING LOSSES
10. Lbs= 2 db	: BEAM SHAPE
11. a= .85	: FACTOR BY WHICH INTEGRATION EFF. IS REDUCED
12. Pf= 1E-08	: FALSE ALARM PROBABILITY
13. Pd= .99	: PROBABILITY OF DETECTION
14. Sav= 1 sq.meters	: TARGET AVERAGE CROSS SECTION
15. YOU 'RE CASE IS	: CASE2

PART a:

1(a). Runab= 600 KM	: THE MAX. UNAB. RANGE

PART b:

2(a). Ls= 5 db	: TOTAL SYSTEM LOSSES
2(b). (S/N)1= 15.9 db	: SIGNAL-TO-NOISE RATIO
2(c). (S/N)1ad= 17.2 db	: ADDITIONAL SIGNAL-TO-NOISE RATIO
2(d). (S/N)tot= 33.1 db	: TOTAL SIGNAL-TO-NOISE RATIO
2(e). I1(n)= 25 db	: INTEGRATION IMR. FACTOR
2(f). Rmax= 758.5743 KM	: MAXIMUM RANGE

```
10  PRINT : PRINT TAB(30); " PROBLEM #4"
20  LPRINT : LPRINT TAB(30); " PROBLEM #4"
30  LPRINT TAB(30); "----------"
40  '******************************
50  REM:   MAIN PROGRAM
60  '******************************
70  GOSUB 160  : GOSUB 310
80  GOSUB 440  : GOSUB 570
90  PRINT : PRINT "DO YOU WANT TO TRY AGAIN FOR DIFFERENT OR THE SAME DATA Y/N ?"
100 INPUT A$
110 IF LEFT$(A$,1)="Y" OR LEFT$(A$,1)="y" THEN 70
120 END
130 '***************************
140 REM : SUBROUTINES
150 '***************************
160 '***** SUBROUTINE THAT INPUTS THE GIVEN DATA *****
170 PRINT : PRINT " ENTER THE OPERATION FREQUENCY f IN GHZ"
180 INPUT f
190 PRINT : PRINT " ENTER THE RATE THAT THE FREQUENCY CHANGES f0 IN GHZ/SEC"
200 INPUT f0
210 PRINT : PRINT " ENTER THE DURATION OF THE CHANGING FREQ. T IN ms"
220 INPUT T
230 PRINT : PRINT " ENTER THE TIME THE FREQ. TAKES TO RETURN TO ITS ORIGINAL VALUE Tr IN
 ms"
240 INPUT Tr
250 PRINT : PRINT " ENTER THE THE RANGE OF THE TARGET R IN Yards"
260 INPUT R
270 PRINT : PRINT " ENTER THE RELATIVE VELOCITY Ur IN ft/sec"
280 INPUT Ur
290 RETURN
300'****************************************
310 REM : SUBROUTINE THAT PRINTS THE INPUT DATA
320'****************************************
330 LPRINT : LPRINT " G I V E N "
340 LPRINT "---------"
```

```
350 LPRINT:LPRINT "1.f=";f;"GHZ"TAB(19);" : OPERATING FREQUENCY"
360 LPRINT:LPRINT "2. f0=";f0;"GHZ/SEC"TAB(19);" :RATE THAT THE FREQUENCY CHANGE"
370 LPRINT:LPRINT "3. T=";T;"ms"TAB(19);" :DURATION OF THE CANGE"
380 LPRINT:LPRINT "4. Tr=";Tr;"ms"TAB(19);" : TIME THE FREQ. NEEDS TO RETURN"
390 LPRINT TAB(17);"     TO ITS ORIGINAL VALUE"
400 LPRINT:LPRINT "5. R=";R;"Yards"TAB(19);" : RANGE OF THE TARGET"
410 LPRINT:LPRINT "6. Ur=";Ur;"ft/sec"TAB(19);" : RELATIVE VELOCITY"
420 RETURN
430*****************************************************
440 REM : SUBROUTINE WHICH CALCULATE AND PRINTS PART a
450*****************************************************
460 LET f0=f0*10^9          'CONVERTION FROM GHZ/SEC TO HZ/SEC
470 LET R=R*.914            'CONVERTION FROM Yards TO Meters
480 LET C=3*10^8             'm/sec
490 LET fr = f0*2*R/C        'FREQUENCY SHIFT
500 PRINT : PRINT : PRINT  " PART a:"
510 LPRINT : LPRINT : LPRINT  " PART a:"
520 LPRINT " -------"
530 PRINT : PRINT " 1(a). fr=";fr/1000;"KHZ";"  : FREQUENCY SHIFT"
540 LPRINT : LPRINT " 1(a). fr=";fr/1000;"KHZ";"  : FREQUENCY SHIFT"
550 RETURN
560***************************************************
570 REM : SUBROUTINE THAT CALCULATE AND PRINTS PART b
580***************************************************
590 LET f=f*10^9                    'CONVERTION FROM GHZ TO HZ
600 LET Ur=Ur*.305                  'CONVERTION FROM ft/sec TO m/s
610 LET l=C/f                       'WAVELENGTH IN meters
620 LET fd=2*Ur/l                    'DOPPLER SHIFT
630 LET dR=R*fd /fr                 'RANGE ERROR IN METERS
640 LET dR1=dR/100                   '% RANGE ERROR
650 PRINT : PRINT : PRINT " PART b:"
660 LPRINT : LPRINT : LPRINT " PART b:"
670 LPRINT " -------"
680 PRINT : PRINT "1(b). fd=";fd;"HZ";"   : DOPPLER SHIFT"
690 LPRINT : LPRINT "1(a). fd=",fd;"HZ";" DOPPLER SHIFT"
```

```
700 PRINT : PRINT "1(b). dR=";dR;"m";" OR";dR/.914;"Yards" ;"      : RANGE ERROR"
710 LPRINT : LPRINT "1(b). dR=";dR;"m";" OR";dR/.914;"Yards" ;"   : RANGE ERROR"
720 PRINT : PRINT "1(c). dR1=";dR1;"m";" OR";dR1/.914;"Yards" ;"      : % RANGE ERROR"
730 LPRINT : LPRINT "1(c). dR1=";dR1;"m";" OR";dR1/.914;"Yards" ;"  : % RANGE ERROR"
740 RETURN
```

PROBLEM #4

GIVEN

1. f= 10.5 GHZ : OPERATING FREQUENCY
2. f0= 2 GHZ/SEC : RATE THAT THE FREQUENCY CHANGE
3. T= 990 ms : DURATION OF THE CANGE
4. Tr= 10 ms : TIME THE FREQ. NEEDS TO RETURN TO ITS ORIGINAL VALUE
5. R= 5000 Yards : RANGE OF THE TARGET
6. Ur= 25 ft/sec : RELATIVE VELOCITY

PART a:

1(a). fr= 60.93333 KHZ : FREQUENCY SHIFT

PART b:

1(a). fd= 533.75 HZ : DOPPLER SHIFT

1(b). dR= 40.03125 m OR 43.79787 Yards : RANGE ERROR

1(c). dR1= .4003125 m OR .4379787 Yards : % RANGE ERROR

```
10  PRINT : PRINT : PRINT TAB(30); " PROBLEM #5"
20  LPRINT : LPRINT : LPRINT TAB(30); " PROBLEM #5"
30  PRINT TAB(30); " ----------"
40  LPRINT TAB(30); " ----------"
50  GOSUB 90   : GOSUB 210
60  GOSUB 310  : GOSUB 410
70  GOTO 510
80 '********************************************
90    REM : SUBROUTINE THAT INPUTS THE DATA
100********************************************
110 PRINT : PRINT " ENTER THE OPERATING FREQ. f IN GHZ"
120 INPUT f
130 PRINT : PRINT " ENTER THE PULSE WIDTH t IN ms"
140 INPUT t
150 PRINT : PRINT " ENTER THE PULSE REPETITIONFREQ. fp IN HZ"
160 INPUT fp
170 PRINT : PRINT " ENTER THE AIRCRAFT'S VELOCITY Uair IN Knots"
180 INPUT Uair
190 RETURN
200********************************************
210 REM : SUBROUTINE THAT PRINTS THE INPUT DATA
220********************************************
230 LPRINT : LPRINT : LPRINT " G I V E N"
240 LPRINT " ---------"
250 LPRINT : LPRINT " 1. f=";f;"GHZ"TAB(18); " : OPERATING FREQ."
260 LPRINT : LPRINT " 2. t=";t;"ms"TAB(18); " : PULSE WIDTH"
270 LPRINT : LPRINT " 3. fp=";fp;"HZ"TAB(18); " : PULSE REPETITION FREQ."
280 LPRINT : LPRINT " 4. Uair=";Uair;"Knots" ; " : AIRCRAFT'S VELOCITY"
290 RETURN
300********************************************
310 REM : SUBROUTINE THAT CALCULATE AND PRINTS Uair
320********************************************
330 LET f=f*10^9
340 LET C=3*10^8
350 LET l=C/f
```

```
360 LET U1b=1*fp/2
370 PRINT :PRINT : PRINT "U1b=";U1b;"m/s";" OR";U1b/.515;"Knots";"  : FIRST BLIND SPEED"
380 LPRINT :LPRINT : LPRINT "U1b=";U1b;"m/s";" OR";U1b/.515;"Knots";"  : FIRST BLIND
 SPEED"
390 RETURN
400'*****************************************************
410  REM : SUBROUTINE THAT FINDS IF THERE IS A DOPPLER AMBIGUITY
420'*****************************************************
430 IF Uair>U1b/.515  THEN GOTO 440  ELSE 460
440 PRINT : PRINT " THERE IS A DOPPLER AMBIGUITY SINCE ";Uair;"Knots"; " >";U1b/.515;"Knots"
450 LPRINT :LPRINT " THERE IS A DOPPLER AMBIGUITY SINCE ";Uair;"Knots"; "
 >";U1b/.515;"Knots"
460 IF Uair<U1b/.515    THEN GOTO 480  ELSE 470
470 IF Uair=U1b/.515    THEN GOTO 480  ELSE 500
480 PRINT : PRINT " THERE ISN'T A DOPPLER AMBIGUITY SINCE ";Uair;"Knots"; " < or
 =";U1b/.515;"Knots"
490 LPRINT : LPRINT " THERE ISN'T A DOPPLER AMBIGUITY SINCE ";Uair;"Knots"; " < or
 =";U1b/.515;"Knots"
500 RETURN
510 PRINT : PRINT " DO YOU WANT TO TRY AGAIN FOR DIFFERENT OR THE SAME DATA Y/N ?"
520 INPUT B$
530 IF LEFT$(B$,1)="Y" OR LEFT$(B$,1)="y"  THEN 30
540 END
```

PROBLEM#5

GIVEN

1. f= 9 GHZ : OPERATING FREQ.
2. t= 1 ms : PULSE WIDTH
3. fp= 1000 HZ : PULSE REPETITION FREQ.
4. Uair= 600 Knots : AIRCRAFT'S VELOCITY

Ulb= 16.66667 m/s OR 32.36246 Knots : FIRST BLIND SPEED

*****THERE IS A DOPPLER AMBIGUITY SINCE 600 Knots > 32.36246 Knots*****

```
10  PRINT : PRINT TAB(30); " PROBLEM #6"
20  PRINT " ----------"
30  LPRINT : LPRINT TAB(30); "PROBLEM #6"
40  LPRINT TAB(30); "-----------"
50  GOSUB 120  : GOSUB 430
60  GOSUB 520  : GOSUB 620
70  PRINT : PRINT " DO YOU WANT TO TRY AGAIN FOR DIFFERENT OR THE SAME DATA Y/N?"
80  INPUT E$
90  IF LEFT$(E$,1)="Y" OR LEFT$(E$,1)="y"  THEN 50
100 END
110****************SUBROUTINES*****************
120 '*      INPUTS THE DATA
130*********************************************
140 PRINT : PRINT " ENTER THE P.R.F fp IN HZ"
150 INPUT fp : PRINT : PRINT "1. fp=";fp;"HZ"
160 PRINT : PRINT " ENTER THE CLUTTER SPECTRAL WIDTH Sc IN HZ"
170 INPUT Sc : PRINT : PRINT "2. Sc=";Sc;"HZ"
180 PRINT : PRINT " ENTER THE NUMBER OF THE DELAY LINE CANCELER"
190 PRINT " WITH OPTIMAL WEIGHTING N"
200 INPUT n : PRINT : PRINT " 3. N=";N
210 PRINT : PRINT " IS THE INPUT DATA CORRECT Y/N?"
220 INPUT A$
230 IF LEFT$(A$,1)="Y"  OR LEFT$(A$,1)="y"  THEN 410
240 PRINT : PRINT "WHAT OF THE FOLLOWING DO YOU WANT TO CHANGE?"
250 PRINT : PRINT " 1. THE P.R.F?"
260 PRINT : PRINT " 2. THE SPECTRAL CLUTTER WIDTH?"
270 PRINT : PRINT " 3. THE NUMBER OF THE DELAY LINE CANCELER?"
280 INPUT B$
290 IF B$="1"  THEN PRINT : PRINT " ENTER THE P.R.F fp IN HZ"
300 IF B$="1"  THEN INPUT fp : PRINT : PRINT " 2. fp=";fp;"HZ" : GOTO 350
310 IF B$="2"  THEN PRINT : PRINT " ENTER THE CLUTTER SPECTRAL WIDTH"
320 IF B$="2"  THEN INPUT Sc : PRINT : PRINT " 2. Sc=";Sc;"HZ" : GOTO 350
330 IF B$="3"  THEN PRINT : PRINT " ENTER THE NUMBER OF THE DELAY LINE CANCELER"
340 IF B$="3"  THEN INPUT N : PRINT : PRINT " 3. N=";N  : GOTO 350
350 PRINT : PRINT " IS EVERYTHING O.K NOW Y/N?"
```

```
360  INPUT C$
370  IF LEFT$(C$,1)="Y" OR LEFT$(C$,1)="y"  THEN GOTO 410
380  PRINT : PRINT "WHAT DO YOU WANT TO CHANGE"
390  PRINT : PRINT "HIT ANY KEY IN YOUR KEYBOARD AND THE COMPUTER WILL WORK FOR YOU"
400  INPUT D$ : GOTO 250
410  RETURN
420'*********************************************
430  '*       PRINTS THE INPUT DATA                   *
440'*********************************************
450  LPRINT : LPRINT " G I V E N"
460  LPRINT "---------"
470  LPRINT : LPRINT " 1.fp=";fp;"HZ" ,": P.R.F"
480  LPRINT : LPRINT " 2. Sc=";Sc;"HZ" ,": CLUTTER SPECTRAL WIDTH"
490  LPRINT : LPRINT " 3. N=";N ,": #OF DELAY LINE CANCELER WITH OPTIMAL WEIGHTING"
500  RETURN
510'******************************************
520  '      CALCULATIONS                        *
530'******************************************
540  PRINT : PRINT " FROM Fig. 4.25 (SKOLNIK Pg. 124) YOU CAN FIND THE IMROVEMENT FACTOR"
550  PRINT " SINCE YOU KNOW"
560  PRINT : PRINT " a. N=";N," : #OF DELAY LINE CANCELER"
570  PRINT "b. Sc/fp=";Sc/fp," : CLUTTER SPECTRAL WIDTH/RADAR P.R.F"
580  PRINT : PRINT " ENTER THE INTEGRATION IMR. FACTOR"
590  INPUT I
600  RETURN
610'*******************************************
620  '          PRINTS THE OUTPUT                *
630'*******************************************
640  PRINT : PRINT : PRINT " OUTPUT"
650  LPRINT : LPRINT : LPRINT " OUTPUT"
660  LPRINT "------"
670  PRINT : PRINT " 1.Sc/fp=";Sc/fp ," : CLUTTER SPECTRAL WIDTH/RADAR P.R.F"
680  LPRINT : LPRINT " 1. Sc/fp=";Sc/fp ," : CLUTTER SPECTRAL WIDTH/RADAR P.R.F"
690  PRINT : PRINT " 2. I=";I;"db" ," : INTEGRATION IMR. FACTOR"
700  LPRINT : LPRINT " 2. I=";I;"db" ,"          : INTEGRATION IMR. FACTOR"
```

```
710 RETURN
```

PROBLEM#6

GIVEN

1. fp= 1000 HZ	: P.R.F
2. Sc= 10 HZ	: CLUTTER SPECTRAL WIDTH
3. N= 3	: #OF DELAY LINE CANCELER WITH OPTIMAL WEIGHTING

OUTPUT

1. Sc/fp= .01	: CLUTTER SPECTRAL WIDTH/RADAR P.R.F
2. I= 55 db	: INTEGRATION IMR. FACTOR

```
10   PRINT : PRINT TAB(30); " PROBLEM #7"
20   PRINT TAB (30); " -----------"
30   REM *********** VARIABLES ************
40    LET C=3*10^8                  'm/s
50   LET PI=3.141593#
60   LET M=.4342945#
70    LET K=1.38*10^-23                   'BOLTZMAN CONSTANT IN J/Deg
80    LET T0=290                          'STANDARD TEMPERATURE IN KELVIN
90   GOSUB 160  : GOSUB 2080 : GOSUB 810  : GOSUB 2260 : GOSUB 930  : GOSUB 2330
100  GOSUB 1160 : GOSUB 2480 : GOSUB 1760 : GOSUB 2640 : GOSUB 1960 : GOSUB 2730
110  PRINT : PRINT "DO YOU WANT TO TRY AGAIN FOR DIFFERENT OR THE SAME DATA Y/N?"
120  INPUT A$
130  IF LEFT$(A$,1)="Y" OR LEFT$(A$,1)="y" THEN 20
140  END
150 '*****************************
160  '*      INPUTS THE DATA
170 '*****************************
180  PRINT : PRINT " ENTER THE PEAK POWER  Pp IN Kw"
190  INPUT Pp : PRINT : PRINT " 1. Pp=";Pp;"Kw"
200  PRINT : PRINT " ENTER THE P.R.F Fp IN HZ"
210  INPUT Fp : PRINT : PRINT " 2. Fp=";Fp;"HZ"
220  PRINT : PRINT " ENTER THE PULSE WIDTH T IN micsec"
230  INPUT T : PRINT : PRINT " 3. T=";T;"micsec"
240  PRINT : PRINT " ENTER THE FALSE ALARM TIME Tfa IN Hrs"
250  INPUT Tfa : PRINT : PRINT " 4. Tfa=";Tfa;"Hrs"
260  PRINT : PRINT " ENTER THE RECEIVER NOISE FIGURE F IN db"
270  INPUT F: PRINT : PRINT " 5. F=";F;"db"
280  PRINT : PRINT " ENTER THE TRANSMITTER FREQ. F0 IN MHZ "
290  INPUT F0 : PRINT : PRINT " 6. F0=";F0;"MHZ"
300  PRINT : PRINT " ENTER THE IF FREQ. Fif IN MHZ"
310  INPUT Fif : PRINT : PRINT " 7. Fif=";Fif;"MHZ"
320  PRINT : PRINT " ENTER THE IF BANDWIDTH Bif IN MHZ"
330  INPUT Bif : PRINT : PRINT " 8. Bif=";Bif;"MHZ"
340  PRINT : PRINT " ENTER THE ANTENNA POWER GAIN G IN db"
350  INPUT G : PRINT : PRINT " 9. G=";G;"db"
```

```
360  PRINT : PRINT " ENTER THE MINIMUM DETECTABLE SIGNAL M.D.S IN dbm"
370  INPUT M.D.S : PRINT : PRINT " 10. M.D.S=";M.D.S;"dbm"
380  PRINT :PRINT " IS THE INPUT DATA CORRECCT Y/N?"
390  INPUT B$
400  IF LEFT$(B$,1)="Y" OR LEFT$(B$,1)="y" THEN 790
410  PRINT : PRINT " WHAT OF THE FOLLOWING DO YOU WANT TO CHANGE?"
420  PRINT : PRINT " 1. THE PEAK POWER?"
430  PRINT : PRINT " 2. THE P.R.F?"
440  PRINT : PRINT " 3. THE PULSE WIDTH?"
450  PRINT : PRINT " 4. THE FALSE ALARM TIME?"
460  PRINT :PRINT " 5. THE RECEIVER NOISE FIFURE?"
470  PRINT : PRINT " 6. THE TRANSMITTER FREQ.?"
480  PRINT : PRINT " 7. THE IF FREQ.?"
490  PRINT : PRINT " 8. THE IF BANDWIDTH?"
500  PRINT : PRINT " 9. ANTENNA POWER GAIN?"
510  PRINT : PRINT " 10. THE MINIMUM DET. SIGNAL?"
520  INPUT C$
530  IF C$="1"  THEN PRINT : PRINT " ENTER THE PEAK POWER Pp IN Kw"
540  IF C$="1"  THEN INPUT Pp : PRINT : PRINT " 1. Pp=";Pp;"Kw" : GOTO 730
550  IF C$="2"  THEN PRINT : PRINT " ENTER THE P.R.F Fp IN HZ"
560  IF C$="2"  THEN INPUT Fp : PRINT : PRINT " 2. Fp=";Fp;"HZ" : GOTO 730
570  IF C$="3"  THEN PRINT : PRINT " ENTER THE PULSE WIDTH T IN micsec"
580  IF C$="3"  THEN INPUT T : PRINT : PRINT " 3. T=";T;"micsec" : GOTO 730
590  IF C$="4"  THEN PRINT : PRINT " ENTER THE FALSE ALARM TIME Tfa IN Hrs"
600  IF C$="4"  THEN INPUT Tfa : PRINT : PRINT " 4. Tfa=";Tfa;"Hrs" : GOTO 730
610  IF C$="5"  THEN PRINT : PRINT " ENTER THE RECEIVER NOISE FIGURE F IN db"
620  IF C$="5"  THEN INPUT F: PRINT : PRINT " 5. F=";F;"db" : GOTO 730
630  IF C$="6"  THEN PRINT : PRINT " ENTER THE TRANSMITTER FREQ. FO IN MHZ "
640  IF C$="6"  THEN INPUT FO : PRINT : PRINT " 6. FO=";FO;"MHZ" : GOTO 730
650  IF C$="7"  THEN PRINT : PRINT " ENTER THE IF FREQ. Fif IN MHZ"
660  IF C$="7"  THEN INPUT Fif : PRINT : PRINT " 7. Fif=";Fif;"MHZ" : GOTO 730
670  IF C$="8"  THEN PRINT : PRINT " ENTER THE IF BANDWIDTH Bif IN MHZ"
680  IF C$="8"  THEN INPUT Bif : PRINT : PRINT " 8. Bif=";Bif;"MHZ" : GOTO 730
690  IF C$="9"  THEN PRINT : PRINT " ENTER THE ANTENNA POWER GAIN G IN db"
700  IF C$="9"  THEN INPUT G : PRINT : PRINT " 9. G=";G;"db" : GOTO 730
```

```
710  IF C$="10" THEN PRINT : PRINT " ENTER THE MINIMUM DETECTABLE SIGNAL M.D.S IN dbm"
720  IF C$="10" THEN INPUT M.D.S : PRINT : PRINT " 10. M.D.S=";M.D.S;"dbm" : GOTO 730
730  PRINT : PRINT " IS EVERYTHING O.K NOW?"
740  INPUT D$
750  IF LEFT$(D$,1)="Y" OR LEFT$(D$,1)="y" THEN GOTO 790
760  PRINT : PRINT " WHAT DO YOU WANT TO CHANGE AGAIN?"
770  PRINT : PRINT "HIT ANY KEY IN YOUR KEYBOARD AND EVERYTHING WILL WORK FOR YOU"
780  INPUT E$ : GOTO 420
790  RETURN
800'*********************************************
810  ' CALCULATION FOR PART 1:
820'*********************************************
830  PRINT : PRINT " NOW IS CALCULATED PART 1:"
840  LET Pp=Pp*10^3                    'CONVERTION FROM Kw TO w
850  LET T=T*10^-6                     'CONVERTION FORM msec TO sec.
860  LET Pav=Pp*Fp*T                   'AVERAGE OUTPUT POWER
870  LET Pav=Pav/1000                  'CONVERTION FROM w TO Kw
880  PRINT : PRINT : PRINT " PART 1:"
890  PRINT "-------"
900  PRINT : PRINT " 1. Pav=Pp*Fp*T=";Pav;"Kw";" : AVERAGE OUTPUT POWER"
910  RETURN
920 '****************************************
930  ' CALCULATION FOR PART 2:
940 '****************************************
950  PRINT : PRINT  " NOW IS CALCULATED PART 2:"
960  PRINT : PRINT : PRINT " PART 2:"
970  PRINT "-------"
980  LET B1f=B1f*10^6                  'CONVERTION FROM MHZ TO HZ
990  LET Pn=K*TO*B1f                   'NOISE POWER
1000 LET Pn1=10*M*LOG(Pn)              'CONVERTION FROM w TO dbw
1010 LET Pn2=Pn1+30                    'CONVERTION FROM dbw TO dbm
1020 PRINT : PRINT "2(a). Pn=K*TO*B1f=";Pn;"W";" OR ";CINT(Pn2);"dbm"; " : NOISE POWER"
1030 IF (Pn2>M.D.S) THEN GOTO 1090  ELSE 1040
1040 IF (Pn2<M.D.S) THEN GOTO 1100  ELSE 1050
1050 IF (Pn2=M.D.S) THEN GOTO 1110
```

```
1060 LET Tfa=Tfa*3600                  'CONVERTION FROM Hrs TO Sec.
1070 LET A=LOG(Tfa*Bif)
1080 LET A=10*M*LOG(A) : GOTO 1120                 'CONVERTION FROM NUMERIC TO db
1090 PRINT : PRINT " 2(b). THE NOISE POWER IS GREATER THAN THE M.D.S" : GOTO 1060
1100 PRINT : PRINT " 2(b). THE NOISE POWER IS SMALLER THAN THE M.D.S" : GOTO 1060
1110 PRINT : PRINT " 2(b). THE NOISE POWER IS EQUAL THE M.D.S" : GOTO 1060
1120 PRINT : PRINT " 2(c). (Vt^2)/(2Y0)=ln(Tfa*Bif)=";CSNG(A);"db";" : R.M.S THRESHOLD POWER
 TO NOISE RATIO"
1130 PRINT : PRINT TAB(55);"IF NO PULSE INTEGRATION IS PERFORMED"
1140 RETURN
1150'****************************************
1160 ' CALCULATION FOR PART 3:
1170'****************************************
1180 PRINT : PRINT " NOW IS CALCULATED PART 3:
1190 PRINT : PRINT " ENTER THE TARGET CROSS SECTION Sc IN SQ METERS"
1200 INPUT Sc
1210 PRINT : PRINT " ENTER THE PROBABILITY OF DETECTION Pd "
1220 INPUT Pd
1230 PRINT : PRINT " ENTER THE # OF PULSES THAT ARE INTEGRATED AFTER POST-DATECTION"
1240 INPUT n
1250 PRINT : PRINT " IS THE INPUT DATA CORRECCT Y/N?"
1260 INPUT F$
1270 IF LEFT$(F$,1)="Y" OR LEFT$(F$,1)="y" THEN 1460
1280 PRINT : PRINT " WHAT OF THE FOLLOWING DO YOU WANT TO CHANGE?"
1290 PRINT : PRINT " 1. THE CROSS SECTION?"
1300 PRINT : PRINT " 2. THE PROBABILITY OF DETECTION?"
1310 PRINT : PRINT " 3. THE # OF INTEGRATED PULSES?"
1320 INPUT G$
1330 IF G$="1"  THEN PRINT : PRINT " ENTER THE CROSS SECTION Sc IN SQ. METERS"
1340 IF G$="1"  THEN INPUT Sc : GOTO 1390
1350 IF G$="2"  THEN PRINT : PRINT " ENTER THE PROBABILITY OF DETECTION Pd"
1360 IF G$="2"  THEN INPUT Pd : GOTO 1390
1370 IF G$="3"  THEN PRINT : PRINT " ENTER THE # OF PULSES TO BE INTEG. n"
1380 IF G$="3"  THEN INPUT n : GOTO 1390
1390 PRINT : PRINT " IS EVERYTHING O.K NOW?"
```

```
1400 INPUT H$
1410 IF LEFT$(H$,1)="Y" OR LEFT$(H$,1)="y" THEN GOTO 1460
1430 PRINT : PRINT " WHAT DO YOU WANT TO CHANGE AGAIN?"
1440 PRINT : PRINT "HIT ANY KEY IN YOUR KEYBOARD AND EVERYTHING WILL WORK FOR YOU"
1450 INPUT I$ : GOTO 1290
1460 LET Pfa=1/(Tfa*B1f)                'PROBABILITY OF FALSE ALARM
1470 PRINT : PRINT " SINCE YOU KNOW THE PROBABILITY OF FALSE ALARM Pfa=";Pfa","
1480 PRINT : PRINT "THE PROBABILITY OF DETECTION Pd=";Pd;"FROM Fig. 2.7 (SKOLNIK Pg. 28)"
1490 PRINT : PRINT " YOU CAN FIND THE (S/N) 1"
1500 PRINT : PRINT " ENTER THE (S/N) I IN db"
1510 INPUT S1
1520 PRINT : PRINT " SINCE YOUR FLUCTUATION CASE IS CASE4 FROM Fig. 2.23 (SKOLNIK Pg.48)"
1530 PRINT : PRINT " YOU CAN FIND THE ADDITIONAL (S/N) 1ad"
1540 PRINT : PRINT " ENTER THE ADDITIONAL (S/N) 1ad IN db"
1550 INPUT S2
1560 LET S3=S1+S2
1570 PRINT : PRINT " FROM Fig. 2.24 (SKOLNIK Pg. 49) YOU CAN FIND THE INTEGR. IMR. FACTOR"
1580 PRINT : PRINT " ENTER THE INTEGR. IMR. FACTOR I1(n) IN db"
1590 INPUT I
1600 LET S4=S3-I
1610 PRINT : PRINT : PRINT " PART 3:"
1620 PRINT "--------"
1630 PRINT : PRINT " 3(a). Sc=";Sc;"sq. m"; " : TARGET CROSS SECTION"
1650 PRINT : PRINT " 3(b). Pd=";Pd; " : PROBABILITY OF DETECTION"
1660 PRINT : PRINT " 3(c). n=";n; " : #OF INTEGRATED PULSES"
1670 PRINT : PRINT " 3(d). YOUR MODEL IS IN CASE4";" : SWERLING MODEL"
1680 PRINT : PRINT " 3(e). Pfa=1/(Tfa*B1f)=";Pfa; " : PROBABILITY OF FALSE ALARM"
1690 PRINT : PRINT " 3(f). (S/N)1=";S1;"db"; " :(S/N)1 FOR ONE PULSE INTEGRATED FROM Fig 2.7"
1700 PRINT : PRINT " 3(g). (S/N)1ad=";S2;"db";" ADDITIONAL (S/N) FROM Fig. 2.7"
1710 PRINT : PRINT " 3(h). (S/N)1tot=";S3;"db"; " : TOTAL (S/N) FROM Fig. 2.23"
1720 PRINT : PRINT " 3(i). I1(n)=";I;"db"; " : INTEGR. IMR. FACTOR FOR 30 PULSES FROM Fig. 2.24"
1730 PRINT : PRINT " 3(k). (S/N)30=(S/N)1tot/I1(n)=";S4;"db"; " : THE MIN. (S/N) REQUIRED TO
 ACHIEVE Pd=0.5"
1740 RETURN
1750'*****************************************
```

```
1760 ' CALCULATIONS FOR PART 4:
1770'*****************************************
1780 PRINT : PRINT " NOW IS CALCULATED PART 4:"
1790 PRINT : PRINT " ENTER THE VALUE OF THE (S/N)min IN db"
1800 INPUT S
1810 PRINT : PRINT " ENTER THE TOTAL SYSTEM LOSSES Ls IN db"
1820 INPUT Ls
1830 LET F1=F/10 : F2=10^F1            'CONVERTION FROM db TO NUMERIC
1840 LET G1=G/10 : G2=10^G1              'CONVERTION FROM db TO NUMERIC
1850 LET Ls1=LS/10 : Ls2=10^Ls1              'CONVERTION FROM db TO NUMERIC
1860 LET F0=F0*10^6 : l=C/F0
1870 LET S5=S/10 : S6=10^S5            'CONVERTION FROM db TO NUMERIC
1880 LET R=(Pp*(G2^2)*(l^2)*Sc/(((4*PI)^3)*K*T0*F2*B1f*S6*Ls2))^(1/4)
1890 PRINT : PRINT : PRINT " PART 4:"
1900 PRINT " -------"
1910 PRINT : PRINT " 4(a). (S/N)min=";S;"db"
1920 PRINT : PRINT " 4(b). Ls=";Ls;"db";" : TOTAL SYSTEM LOSSES"
1930 PRINT : PRINT " 4(c).
R=(Pp*(G^2)*(l^2)*Sc/(((4*PI)^3)*(K*T0*F*B1f)*(S/N)min*Ls))^(1/4)=";CSNG(R/1000);"KM";
MAX.RANGE"
1940 RETURN
1950'*************************************
1960 ' CALCULATIONS FOR PART 5:
1970'*************************************
1980 PRINT : PRINT " NOW IS CALCULATED PART 5:"
1990 PRINT : PRINT " ENTER THE MIN. RADAR RANGE R1 IN KM"
2000 INPUT R1
2010 LET TR=2*R1*1000/C-T              'RECOVERY TIME
2020 PRINT : PRINT : PRINT " PART 5:"
2030 PRINT " -------"
2040 PRINT : PRINT " 5(a). R1=";R1;"KM"; " : MIN. RADAR RANGE"
2050 PRINT : PRINT " 5(b). TR=(2*R1*1000/C)-T=";TR*10^6;"micsec"; " : RECOVERY TIME"
2060 RETURN
2070'****************************************
2080 ' SUBROUTINE THAT PRINTS THE INPUT DATA
```

```
2090'*******************************************
2100 LPRINT : LPRINT TAB(30); " PROBLEM #7"
2110 LPRINT TAB (30);" -----------"
2120 LPRINT : LPRINT : LPRINT " G I V E N"
2130 LPRINT "---------"
2140 LPRINT : LPRINT " 1.Pp=";Pp;"Kw", " : PEAK POWER"
2150 LPRINT : LPRINT " 2. Fp=";Fp;"HZ", " : P.R.F"
2160 LPRINT : LPRINT " 3.T=";T;"micsec", " : PULSE WIDTH"
2170 LPRINT : LPRINT " 4. Tfa=";Tfa;"Hrs", " : FALSE ALARM TIME"
2180 LPRINT : LPRINT " 5. F=";F;"db", "            : RECEIVER NOISE FIGURE"
2190 LPRINT : LPRINT " 6. FO=";FO;"MHZ", " : TRANSMITTED FREQ."
2200 LPRINT : LPRINT " 7. Fif=";Fif;"MHZ", " : IF FREQUENCY"
2210 LPRINT : LPRINT " 8. Bif=";Bif;"MHZ", " : IF BANDWIDTH"
2220 LPRINT : LPRINT " 9. G=";G;"db", "            : ANTENNA POWER GAIN"
2230 LPRINT : LPRINT " 10.M.D.S=";M.D.S;"dbm", " : MIN. DETECTABLE SIGNAL"
2240 RETURN
2250'*******************************************
2260 ' SUBROUTINE THAT PRINTS PART 1:
2270'*******************************************
2280 LPRINT : LPRINT : LPRINT " PART 1:"
2290 LPRINT "-------"
2300 LPRINT : LPRINT " 1.Pav=Pp*Fp*T=";Pav;"Kw";" : AVERAGE OUTPUT POWER"
2310 RETURN
2320'*********************************
2330 ' SUBROUTINE THAT PRINTS PART 2:
2340'*********************************
2350 LPRINT : LPRINT : LPRINT " PART 2:"
2360 LPRINT "-------"
2370 LPRINT : LPRINT " 2(a).Pn=K*TO*Bif=";Pn;"W";" OR ";CINT(Pn2);"dbm"; " : NOISE POWER"
2380 IF (Pn2>M.D.S)  THEN GOTO 2410  ELSE 2390
2390 IF (Pn2<M.D.S)  THEN GOTO 2420  ELSE 2400
2400 IF (Pn2=M.D.S)  THEN GOTO 2430
2410 LPRINT : LPRINT " 2(b). THE NOISE POWER IS GREATER THAN THE M.D.S" : GOTO 2440
2420 LPRINT : LPRINT " 2(b). THE NOISE POWER IS SMALLER THAN THE M.D.S" : GOTO 2440
2430 LPRINT : LPRINT " 2(b). THE NOISE POWER IS EQUAL THE M.D.S"
```

```
2440 LPRINT :LPRINT " 2(c).(Vt^2)/(2Y0)=ln(Tfa*B1f)=";CSNG(A);"db";" : R.M.S THRESHOLD
 POWER TO NOISE RATIO"
2450 LPRINT : LPRINT TAB(55);"IF NO PULSE INTEGRATION IS PERFORMED"
2460 RETURN
2470'***********************************
2480 ' SUBROUTINE THAT PRINTS PART 3:
2490'***********************************
2500 LPRINT : LPRINT : LPRINT " PART 3:"
2510 LPRINT "-------"
2520 LPRINT : LPRINT " 3(a). Sc=";Sc;"sq. m"," :TARGET CROSS SECTION"
2530 LPRINT : LPRINT " 3(b). Pd=";Pd," : PROBABILITY OF DETECTION"
2540 LPRINT : LPRINT " 3(c). n=";n, " : #OF INTEGRATED PULSES"
2550 LPRINT : LPRINT " 3(d). YOUR MODEL IS IN CASE4", " : SWERLING MODEL"
2560 LPRINT : LPRINT " 3(e). Pfa= 1/(Tfa*B1f)=";Pfa, " : PROBABILITY OF FALSE ALARM"
2570 LPRINT : LPRINT " 3(f). (S/N)1=";S1;"db", " : (S/N)1 FOR ONE PULSE INTEGRATED FROM Fig
 2.7"
2580 LPRINT : LPRINT " 3(g). (S/N)1ad=";S2;"db", " : ADDITIONAL (S/N) FROM Fig. 2.7"
2590 LPRINT : LPRINT  " 3(h). (S/N)1tot=";S3;"db", " : TOTAL (S/N) FROM Fig. 2.23"
2600 LPRINT : LPRINT " 3(i). Ii(n)=";I;"db", " : INTEGR. IMR. FACTOR FOR 30 PULSES FROM Fig.
 2.24"
2610 LPRINT : LPRINT " 3(k). (S/N)30=(S/N)tot/Ii(n)=";S4;"db", " : THE MIN. (S/N) REQUIRED TO
 ACHIEVEPd=0.5"
2620 RETURN
2630'*************************************
2640 ' SUBROUTINE THAT PRINTS PART 4:
2650'*************************************
2660 LPRINT : LPRINT : LPRINT " PART 4:"
2670 LPRINT "-------"
2680 LPRINT : LPRINT " 4(a). (S/N)min=";S;"db"
2690 LPRINT : LPRINT " 4(b). Ls=";Ls;"db"; " : TOTAL SYSTEM LOSSES"
2700 LPRINT : LPRINT " 4(c).
 R=(Pp*(G^2)*(l^2)*Sc/(((4*PI)^3)*(K*T0*F*BIF)*(S/N)min*Ls))^(1/4)=";CSNG(R/1000);"KM";
 MAX.RANGE"
2710 RETURN
2720'*********************************
```

```
2730 ' SUBROUTINE THAT PRINTS PART 5:
2740'*********************************
2750 LPRINT : LPRINT : LPRINT " PART 5:"
2760 LPRINT "-------"
2770 LPRINT : LPRINT "5(a). R1=";R1;"KM"; " : MIN. RADAR RANGE"
2780 LPRINT :LPRINT "5(b). TR=(2*R1*1000/C)-T=";TR*10^6;"micsec"; " : RECOVERY TIME"
2790 RETURN
```

PROBLEM#7

GIVEN

1. Pp= 200 Kw	: PEAK POWER
2. Fp= 300 HZ	: P.R.F
3. T= 60 micsec	: PULSE WIDTH
4. Tfa= 2.2 Hrs	: FALSE ALARM TIME
5. F= 6.5 db	: RECEIVER NOISE FIGURE
6. F0= 400 MHZ	: TRANSMITTED FREQ.
7. Fif= 120 MHZ	: IF FREQUENCY
8. Bif= 1.25 MHZ	: IF BANDWIDTH
9. G= 21 db	: ANTENNA POWER GAIN
10. M.D.S=-115 dbm	: MIN. DETECTABLE SIGNAL

PART 1:

1. Pav=Pp*Fp*T= 3.6 Kw : AVERAGE OUTPUT POWER

PART 2:

2(a). Pn=K*T0*Bif= 5.0025d-15 W OR -113 dbm : NOISE POWER

2(b). THE NOISE POWER IS GREATER THAN THE M.D.S

2(c). (Vt^2)/(2Y0)=ln(Tfa*Bif)= 13.6203 db : R.M.S THRESHOLD POWER TO NOISE RATIO IF NO PULSE INTEGRATION IS PERFORMED

PART 3:

3(a). Sc= 1 sq. m	:TARGET CROSS SECTION
3(b). Pd= .5	: PROBABILITY OF DETECTION
3(c). n= 30	: #OF INTEGRATED PULSES
3(d). YOUR MODEL IS IN CASE4	: SWERLING MODEL
3(e). Pfa= 1/(Tfa*Bif)= 1E-10	: PROBABILITY OF FALSE ALARM
3(f). (S/N)1= 13.6 db	: (S/N)1 FOR ONE PULSE INTEGRATED FROM Fig 2.7
3(g). (S/N)1ad= 1 db	: ADDITIONAL (S/N)
3(h). (S/N)1tot= 14.6 db	: TOTAL (S/N)

PART 4:

4(a).(S/N)min= 4 db

4(b). Ls= 1 db: TOTAL SYSTEM LOSSES

4(c).R=(Pp*(G^2)*(l^2)*Sc/(((4*PI)^3)*(K*TO*F*BIF)*(S/N)min*Ls))^(1/4)=59.7151 [illegible] RANGE

PART 5:

5(a). R1= 10.5 KM: MIN. RADAR RANGE

5(b). TR=(2*R1*1000/C)-T= 10 micsec: RECOVERYTIME

```
10  PRINT : PRINT TAB(30); " PROBLEM #8"
20  PRINT TAB (30); " -----------"
30  LPRINT : LPRINT TAB(30); " PROBLEM #8"
40  LPRINT TAB (30); " -----------"
50  GOSUB 120  : GOSUB 490
60  GOSUB 650  : GOSUB 790
70  PRINT : PRINT " DO YOU WANT TO TRY AGAIN FOR DIFFERENT OR THE SAME DATA Y/N?"
80  INPUT A$
90  IF LEFT$(A$,1)="Y" OR LEFT$(A$,1)="y" THEN 50
100 END
110 '*****************************
120 '*      INPUTS THE DATA          *
130 '*****************************
140 PRINT : PRINT " ENTER THE OPERATING FREQ. f IN GHZ"
150 INPUT f : PRINT : PRINT " 1. f=";f;"GHZ"
160 PRINT : PRINT " ENTER THE P.R.F fp IN HZ"
170 INPUT fp : PRINT : PRINT " 2. fp=";fp;"HZ"
180 PRINT : PRINT " FROM F1g. 13 (SKOLNIK Handbook Pg. 17-16) AND FOR CHAFF YOU CAN FIND"
190 PRINT " THE RANGE OF THE R.M.S VELOCITY SPREAD"
200 PRINT : PRINT " ENTER THE LOWER VALUE Su1 OF THE R.M.S VELOCITY SPREAD IN m/s"
210 INPUT Su1 : PRINT : PRINT " 3. Su1=";Su1;"m/s"
220 PRINT : PRINT " ENTER THE UPPER VALUE Su2 OF THE R.M.S VELOCITY SPREAD IN m/s"
230 INPUT Su2 : PRINT : PRINT " 4. Su2=";Su2;"m/s"
240 PRINT : PRINT " IS THE INPUT DATA CORRECCT Y/N?"
250 INPUT B$
260 IF LEFT$(B$,1)="Y" OR LEFT$(B$,1)="y" THEN 470
270 PRINT : PRINT " WHAT OF THE FOLLOWING DO YOU WANT TO CHANGE?"
280 PRINT : PRINT " 1. THE OPERATING FREQ.?"
290 PRINT : PRINT " 2. THE P.R.F?"
300 PRINT : PRINT " 3. THE LOWER VALUE OF THE R.M.S VELOCITY SPREAD?"
310 PRINT : PRINT " 4. THE UPPER VALUE OF THE R.M.S VELOCITY SPREAD?"
320 INPUT C$
330 IF C$="1"  THEN PRINT : PRINT " ENTER THE OPERATING FREQ. f IN GHZ"
340 IF C$="1"  THEN INPUT f : PRINT : PRINT " 1. f=";f;"GHZ" : GOTO 410
350 IF C$="2"  THEN PRINT : PRINT " ENTER THE P.R.F fp IN HZ"
```

```
360  IF C$="2"  THEN INPUT fp : PRINT : PRINT " 2. fp=";fp;"HZ" : GOTO 410
370  IF C$="3"  THEN PRINT : PRINT " ENTER THE LOWER VALUE OF THE R.M.S VELOCITY SPREAD
 Su1 IN m/s"
380  IF C$="3"  THEN INPUT Su1 : PRINT : PRINT " 3. Su1=";Su1;"m/s" : GOTO 410
390  IF C$="4"  THEN PRINT : PRINT " ENTER THE UPPER VALUE OF THE R.M.S VELOCITY SPREAD
 Us2 IN m/s"
400  IF C$="4"  THEN INPUT Su2 : PRINT : PRINT " 4. Us2=";Us2;"m/s" : GOTO 410
410  PRINT : PRINT " IS EVERYTHING O.K NOW?"
420  INPUT D$
430  IF LEFT$(D$,1)="Y"  OR LEFT$(D$,1)="y" THEN GOTO 470
440  PRINT : PRINT " WHAT DO YOU WANT TO CHANGE AGAIN?"
450  PRINT : PRINT "HIT ANY KEY IN YOUR KEYBOARD AND EVERYTHING WILL WORK FOR YOU"
460  INPUT E$ : GOTO 280
470  RETURN
480'*******************************************
490  '        PRINTS THE INPUT DATA
500'*******************************************
510  PRINT : PRINT " G I V E N "
520  PRINT " ---------"
530  LPRINT : LPRINT " G I V E N"
540  LPRINT " ---------"
550  PRINT : PRINT " 1. f=";f;"GHZ"TAB(20);" : OPERATING FREQUENCY"
560  LPRINT : LPRINT " 1. f=";f;"GHZ"TAB(20);" : OPERATING FREQUENCY"
570  PRINT : PRINT " 2. fp=";fp;"HZ"TAB(20);" : P.R.F"
580  LPRINT : LPRINT " 2. fp=";fp;"HZ"TAB(20);" : P.R.F"
590  PRINT : PRINT " 3. Su1=";Su1;"m/s"TAB(20);" : LOWER VALUE OF THE R.M.S VELOCITY
 SPREAD"
600  LPRINT : LPRINT " 3. Su1=";Su1;"m/s"TAB(20);" : LOWER VALUE OF THE R.M.S VELOCITY
 SPREAD"
610  PRINT : PRINT " 4. Su2=";Su2;"m/s"TAB(20);" : UPPER VALUE OF THE R.M.S VELOCITY
 SPREAD"
620  LPRINT : LPRINT " 4. Su2=";Su2;"m/s"TAB(20);" : UPPER VALUE OF THE R.M.S VELOCITY
 SPREAD"
630  RETURN
640'************************************
```

```
650 '     CALCULATIONS
660'************************************
670  LET f=f*10^9              'convertion from GHz to Hz
680  LET C=3*10^8              'm/s
690 LET PI=3.14159
700 LET a1=C^2/(8*Su1^2)   'parameter dependent upon clutter
710 LET a2=C^2/(8*Su2^2)     'parameter dependent upon clutter
720 LET I2c1=a1^2*fp^4/(2*PI^4*f^4)  'imrovement factor
730 LET I2c2 =a2^2*fp^4/(2*PI^4*f^4)    'imrovement factor
740 LET M=.4342945#
750  LET I2c1=CINT(10*M*LOG(I2c1))           'convertion from numeric to db
760  LET I2c2=CINT(10*M*LOG(I2c2))             'convertion from numeric to db
770 RETURN
780'************************************
790 '     PRINTS THE OUTPUT
800'************************************
810 PRINT :PRINT " OUTPUT"
820 PRINT "------"
830 LPRINT :LPRINT " OUTPUT"
840 LPRINT "------"
850 PRINT :PRINT " 1.a1=C^2/(8*Su1^2)=";a1,": PARAMETER DEPENDENT UPON CLUTTER"
860 LPRINT :LPRINT " 1.a1=C^2/(8*Su1^2)=";a1,": PARAMETER DEPENDENT UPON CLUTTER"
870 PRINT :PRINT "2.a2=C^2/(8*Su2^2)=";a2,": PARAMETER DEPENDENT UPON CLUTTER"
880 LPRINT :LPRINT "2.a2=C^2/(8*Su2^2)=";a2,": PARAMETER DEPENDENT UPON CLUTTER"
890 PRINT :PRINT "3.I2c1=a1*fp^4/(2*PI^4*f^4)=";I2c1;"db",": IMPROVEMENT FACTOR"
900 LPRINT:LPRINT "3.I2c1=a1*fp^4/(2*PI^4*f^4)=";I2c1;"db",": IMPROVEMENT FACTOR"
910 PRINT :PRINT "4.I2c2=a2*fp^4/(2*PI^4*f^4)=";I2c2;"db",": IMPROVEMENT FACTOR"
920 LPRINT:LPRINT "4.I2c2=a2*fp^4/(2*PI^4*f^4)=";I2c2;"db",": IMPROVEMENT FACTOR"
930 PRINT :PRINT "THE IMROVEMENT FACTOR IS FROM";I2c1;"db";" TO";I2c2;"db"
940 LPRINT :LPRINT "THE IMROVEMENT FACTOR IS FROM";I2c1;"db";" TO";I2c2;"db"
950 RETURN
```

PROBLEM #8

GIVEN

1. f= 6 GHZ : OPERATING FREQUENCY
2. fp= 1000 HZ : P.R.F
3. Su1= .4 m/s : LOWER VALUE OF THE R.M.S VELOCITY SPREAD
4. Su2= 1 m/s : UPPER VALUE OF THE R.M.S VELOCITY SPREAD

OUTPUT

1. a1=C^2/(8*Su1^2)= 7.03125D+16 : PARAMETER DEPENDENT UPON CLUTTER
2. a2=C^2/(8*Su2^2)= 1.125D+16 : PARAMETER DEPENDENT UPON CLUTTER
3. I2c1=a1*fp^4/(2*PI^4*f^4)= 43 db : IMPROVEMENT FACTOR
4. I2c2=a2*fp^4/(2*PI^4*f^4)= 27 db : IMPROVEMENT FACTOR

**** THE IMROVEMENT FACTOR IS FROM 43 db TO 27 db ****

```
10  PRINT : PRINT TAB(30); " PROBLEM #9"
20  PRINT TAB (30); " -----------"
30  LPRINT : LPRINT TAB(30); " PROBLEM #9"
40  LPRINT TAB (30); " -----------"
50  GOSUB 120  : GOSUB 420
60  GOSUB 560  : GOSUB 630
70  PRINT : PRINT " DO YOU WANT TO TRY AGAIN FOR DIFFERENT OR THE SAME DATA Y/N?"
80  INPUT A$
90  IF LEFT$(A$,1)="Y"  OR LEFT$(A$,1)="y"  THEN 50
100 END
110 '******************************
120 '*      INPUTS THE DATA          *
130 '******************************
140 PRINT : PRINT " ENTER THE MEAN FREQ. OF THE CLUTTER SPECTRUM IN HZ"
150 INPUT fe : PRINT : PRINT " 1. fe=";fe;"HZ"
160 PRINT : PRINT " ENTER THE P.R.F fp IN HZ"
170 INPUT fp : PRINT : PRINT " 2. fp=";fp;"HZ"
180 PRINT : PRINT " ENTER THE R.M.S CLUTTER SPREAD Sc IN HZ"
190 INPUT Sc : PRINT : PRINT " 3. Sc=";Sc;"HZ"
200 PRINT : PRINT " IS THE INPUT DATA CORRECCT Y/N?"
210 INPUT B$
220 IF LEFT$(B$,1)="Y"  OR LEFT$(B$,1)="y"  THEN 400
230 PRINT : PRINT " WHAT OF THE FOLLOWING DO YOU WANT TO CHANGE?"
240 PRINT : PRINT " 1. THE MEAN FREQ. OF THE CLUTTER SPECTRUM?"
250 PRINT : PRINT " 2. THE P.R.F?"
260 PRINT : PRINT "3. THE R.M.S CLUTTER SPREAD?"
270 INPUT C$
280 IF C$="1"   THEN PRINT : PRINT " ENTER THE MEAN FREQ. OF THE CLUTTER SPECTRUM fe IN
 HZ"
290 IF C$="1"   THEN INPUT fe : PRINT : PRINT " 1. fe=";fe;"HZ" : GOTO 340
300 IF C$="2"   THEN PRINT : PRINT " ENTER THE P.R.F fp IN HZ"
310 IF C$="2"   THEN INPUT fp : PRINT : PRINT " 2. fp=";fp;"HZ" : GOTO 340
320 IF C$="3"   THEN PRINT : PRINT " ENTER THE R.M.S CLUTTER SPREAD Sc IN HZ"
330 IF C$="3"   THEN INPUT Sc : PRINT : PRINT " 3. Sc=";Sc;"HZ" : GOTO 340
340 PRINT : PRINT " IS EVERYTHING O.K NOW?"
```

```
350  INPUT D$
360  IF LEFT$(D$,1)="Y"  OR LEFT$(D$,1)="y" THEN GOTO 400
370  PRINT : PRINT " WHAT DO YOU WANT TO CHANGE AGAIN?"
380  PRINT : PRINT "HIT ANY KEY IN YOUR KEYBOARD AND EVERYTHING WILL WORK FOR YOU"
390  INPUT E$ : GOTO 230
400  RETURN
410'*******************************************
420  '        PRINTS THE INPUT DATA
430'*******************************************
440  PRINT : PRINT " G I V E N "
450  PRINT "---------"
460  LPRINT : LPRINT " G I V E N"
470  LPRINT "---------"
480  PRINT : PRINT " 1. fe=";fe;"HZ"TAB(20);" : MEAN FREQUENCY OF THE CLUTTER SPECTRUM "
490  LPRINT : LPRINT " 1. fe=";fe;"HZ"TAB(20);" : MEAN FREQUENCY OF THE CLUTTER SPECTRUM "
500  PRINT : PRINT " 2. fp=";fp;"HZ"TAB(20);" : P.R.F"
510  LPRINT : LPRINT " 2. fp=";fp;"HZ"TAB(20);" : P.R.F"
520  PRINT : PRINT " 3. Sc=";Sc;"HZ"TAB(20);" : R.M.S CLUTTER SPREAD"
530  LPRINT : LPRINT " 3. Sc=";Sc;"HZ"TAB(20);" : R.M.S CLUTTER SPREAD"
540  RETURN
550'************************************
560  '      CALCULATIONS
570'************************************
590  LET F1=Sc/fp        'r.m.s clutter spread/pulse rep.freq.
600  LET F2=fe/fp        'mean freq. of the clutter spectrum/pulse rep. freq.
610  RETURN
620'************************************
630  '  PRINTS THE OUTPUT
640'************************************
650  PRINT : PRINT : PRINT " OUTPUT"
660  PRINT "------"
670  LPRINT : LPRINT : LPRINT " OUTPUT"
680  LPRINT "------"
690  PRINT : PRINT " 1. Sc/fp=";F1;" : R.M.S CLUTTER SPREAD/P.R.F"
700  PRINT : PRINT " 2. fe/fp="F2;" : MEAN FREQ. OF THE CLUTTER SPECTRUM/P R.F"
```

```
710 LPRINT :LPRINT " 1. Sc/fp=";F1;" : R.M.S CLUTTER SPREAD/P.R.F"
720 LPRINT : LPRINT " 2. fe/fp="F2;" : MEAN FREQ. OF THE CLUTTER SPECTRUM/P.R.F"
730 PRINT : PRINT " SINCE YOU KNOW THAT Sc/fp=";F1;" AND ";"fe/fp=";F2
740 PRINT : PRINT " FROM Fig. 4.34 (SKOLNIK Pg. 141) YOU CAN FIND THE IMR. FACTOR IN db"
750 PRINT : PRINT " ENTER THE VALUE OF THE IMR. FACTOR"
760 INPUT I
770 PRINT : PRINT " 3. I=";I;"db";" : REDUCTION OF THE IMR. FACTOR FOR THE NEAR IDEAL CASE,"
780 PRINT : PRINT TAB(16);"ASSUMING A THREE PULSE CANCELER"
790 LPRINT : LPRINT " 3. I=";I;"db";"    : REDUCTION OF THE IMR. FACTOR FOR THE NEAR IDEAL
 CASE,"
800 LPRINT : LPRINT TAB(19);"ASSUMING A THREE PULSE CANCELER"
810 RETURN
```

PROBLEM#9

GIVEN

1. fe= 30 HZ : MEAN FREQUENCY OF THE CLUTTER SPECTRUM
2. fp= 300 HZ : P.R.F
3. Sc= 3 HZ : R.M.S CLUTTER SPREAD

OUTPUT

1. Sc/fp= .01 : R.M.S CLUTTER SPREAD/P.R.F
2. fe/fp= .1 : MEAN FREQ. OF THE CLUTTER SPECTRUM/P.R.F
3. I= 24 db : REDUCTION OF THE IMR. FACTOR FOR THE NEAR IDEAL CASE, ASSUMING A THREE PULSE CANCELER

```
10  PRINT : PRINT TAB(30); " PROBLEM #10"
20  PRINT TAB (30); " -----------"
30  GOSUB 100  : GOSUB 500
40  GOSUB 700  : GOSUB 880
50  PRINT : PRINT " DO YOU WANT TO TRY AGAIN FOR DIFFERENT OR THE SAME DATA Y/N?"
60  INPUT A$
70  IF LEFT$(A$,1)-"Y" OR LEFT$(A$,1)="y" THEN 30
80  END
90 '******************************
100 '*      INPUTS THE DATA          *
110'******************************
120 PRINT : PRINT " ENTER THE OPERATING FREQ. f0 IN MHZ"
130 INPUT f0 : PRINT : PRINT " 1. f0=";f0;"MHZ"
140 PRINT : PRINT " ENTER THE SCAN ANGLE OFF,ANTENNA CENTER AXIS THs IN Deg."
150 INPUT THs : PRINT : PRINT " 2. THs=";THs;"Deg."
160 PRINT : PRINT " ENTER THE SEPARATION BETWEEN THE TWO ADJACENT ARRAY ELEMENTS d1
 IN cm"
170 INPUT d1 : PRINT : PRINT "3. d1=";d1;"cm"
180 PRINT : PRINT " ENTER THE DIAMETER OF THE PHASE ARRAY ANTENNA d IN m"
190 INPUT d : PRINT : PRINT " 4. d=";d;"m"
200 PRINT : PRINT " ENTER THE OFF CENTER ANGLE WHERE THE ANTENNA IS STEERED TH0 IN
 Deg."
210 INPUT TH0 : PRINT : PRINT "5. TH0=";TH0;"Deg."
220 PRINT : PRINT " IS THE INPUT DATA CORRECT Y/N?"
230 INPUT B$
240 IF LEFT$(B$,1)="Y" OR LEFT$(B$,1)="y" THEN 480
250 PRINT : PRINT " WHAT OF THE FOLLOWING DO YOU WANT TO CHANGE?"
260 PRINT : PRINT "  1. THE OPERATING FREQ?"
270 PRINT : PRINT " 2. THE SCAN ANGLE OFF,ANTENNA CENTER AXIS?"
280 PRINT : PRINT " 3. THE SEPARATION BETWEEN THE TWO ADJACENT ARRAY ELEMENTS?"
290 PRINT : PRINT " 4. THE DIAMETER OF THE PHASE ARRAY ANTENNA?"
300 PRINT : PRINT " 5. THE OFF CENTER ANGLE WHERE THE ANTENNA IS STEERED?"
310 INPUT C$
320 IF C$="1"   THEN PRINT : PRINT " ENTER THE OPERATING FREQ.IN MHZ"
330 IF C$="1"   THEN INPUT f0 : PRINT : PRINT " 1. f0=";f0;"MHZ" : GOTO 420
340 IF C$="2"   THEN PRINT : PRINT " ENTER THE SCAN ANGLE OFF,ANTENNA CENTER AXIS THs IN
 Deg."
350 IF C$="2"   THEN INPUT THs : PRINT : PRINT " 2. THs=";THs;"Deg." : GOTO 420
360 IF C$="3"   THEN PRINT : PRINT "ENTER THE SEPARATION BETWEEN THE TWO ADJACENT
```

```
ARRAYELEMENTS d1 IN cm"
370  IF C$="3"   THEN INPUT d1 : PRINT : PRINT " 3. d1=";d1;"cm" : GOTO 420
380  IF C$="4"   THEN PRINT : PRINT " ENTER THE DIAMETER OF THE PHASE ARRAY ANTENNA d IN
 m"
390  IF C$="4"   THEN INPUT d : PRINT : PRINT " 4. d=";d;"m" : GOTO 420
400  IF C$="5"   THEN PRINT : PRINT " ENTER THE OFF CENTER ANGLE WHERE THE ANTENNA IS
 STEEREDTHO IN Deg."
410  IF C$="5"   THEN INPUT THO : PRINT : PRINT "5] THO=";THO;"Deg." : GOTO 420
420  PRINT : PRINT " ISEVERYTHING O.K NOW?"
430  INPUT D$
440  IF LEFT$(D$,1)="Y" OR LEFT$(D$,1)="y" THEN GOTO 480
450  PRINT : PRINT " WHAT DO YOU WANT TO CHANGE AGAIN?"
460  PRINT : PRINT "HIT ANY KEY IN YOUR KEYBOARD AND EVERYTHING WILL WORK FOR YOU"
470  INPUT E$ : GOTO 260
480  RETURN
490'*******************************************
500  '          PRINTS THE INPUT DATA
510'*******************************************
520  PRINT : PRINT " G I V E N"
530  PRINT " ---------"
540  PRINT : PRINT " 1. f0=";f0;"MHZ", " : OPERATING FREQUENCY"
550  PRINT : PRINT " 2. THs=";THs;"Deg.", " :  SCAN ANGLE OFF,ANTENNA CENTER AXIS"
560  PRINT : PRINT " 3. d1="      ;  m", "            : SEPARATION BETWEEN THE TWO ADJACENT
 ARRAYELEMENTS"
570  PRINT : PRINT " 4. d=";d;"m  , "            : DIAMETER OF THE PHASE ARRAY ANTENNA"
580  PRINT : PRINT " 5. THO=";THO, "Deg.","  : THE OFF CENTER ANGLE WHERE THE ANTENNA IS
 STEERED"
590  LPRINT :LPRINT TAB(30);" PROBLEM # 10"
600 LPRINT TAB(30);" -----------"
610  LPRINT : LPRINT " G I V E N"
620  LPRINT " ---------"
630  LPRINT : LPRINT " 1. f0=";f0;"MHZ", " : OPERATING FREQUENCY"
640  LPRINT : LPRINT " 2. THs=";THs;"Deg.", " :  SCAN ANGLE OFF,ANTENNA CENTER AXIS"
650  LPRINT : LPRINT " 3. d1=";d1;"cm", "            : SEPARATION BETWEEN THE TWO ADJACENT
 ARRAYELEMENTS"
660  LPRINT : LPRINT " 4. d=";d;"m", "            : DIAMETER OF THE PHASE ARRAY ANTENNA"
670  LPRINT : LPRINT " 5. THO=";THO, "Deg.","  : THE OFF CENTER ANGLE WHERE THE ANTENNA IS
 STEERED"
680  RETURN
```

```
690'************************************
700 '      CALCULATION FOR PART1 :
710'************************************
720 LET PI=3.141593#
730 LET C=3*10^8
740 LET f0=f0*10^6
750 LET 1=C/f0
760 LET d1=d1/100
770 LET PHI=2*PI*(d1/1)*SIN(THO*PI/180)
780 LET PHI1=180*PHI/PI          'Deg.
790'************************************
800 '      CALCULATION FOR PART2 :
810'************************************
820 LET K=.866
830 LET N=1
840 LET B.W=K*1/(N*d*(COS(THO*PI/180)))
850 LET B.W1=180*B.W/PI              'Deg.
860 RETURN
870'************************************
880 '      PRINTOUT FOR PART1 and PART 2
890'************************************
900 PRINT : PRINT : PRINT " PART1:"
910 PRINT "-----"
920 LPRINT : LPRINT : LPRINT " PART 1:
930 LPRINT "-----"
940 PRINT : PRINT " 1.PHI=2*PI*(d/1)*SIN(THO)=";CSNG(PHI);"rad";" OR ";CSNG(PHI1);"Deg.";"
 : PHASE DIFFERENCE BETWEEN TWO ARRAY ELEMENTS"
950 LPRINT :LPRINT " 1.PHI=2*PI*(d/1)*SIN(THO)=";CSNG(PHI);"rad";" OR ";CSNG(PHI1);"Deg.";"
  : PHASE DIFFERENCE BETWEEN TWO ARRAY ELEMENTS"
960 PRINT : PRINT : PRINT " PART2:"
970 PRINT "------"
980 LPRINT : LPRINT : LPRINT " PART2:"
990 LPRINT "------"
1000 PRINT : PRINT " 2.B.W=K*1/(N*d1*COS(THO))=";CSNG(B.W);"rad";" OR ";CSNG(B.W1);"Deg.";
 "   : BEAMWIDTH AT 10 Deg. FOR THE SAME OUTPUT OF ARRAY ELEMENT"
1010 LPRINT :LPRINT " 2.B.W=K*1/(N*d1*COS(THO))=";CSNG(B.W);"rad";" OR
 ";CSNG(B.W1);"Deg.";"   : BEAMWIDTH AT 10 Deg. FOR THE SAME OUTPUT OF ARRAY ELEMENT"
1020 RETURN
```

PROBLEM # 10

GIVEN

1. f0= 1250 MHZ : OPERATING FREQUENCY
2. THs= 60 Deg. : SCAN ANGLE OF ANTENNA CENTER AXIS
3. d1= 20 cm : SEPARATION BETWEEN THE TWO ADJACENT ARRAY ELEMENTS
4. d= 29 m : DIAMETER OF THE PHASE ARRAY ANTENNA
5. TH0= 10 Deg. : THE OFF CENTER ANGLE WHERE THE ANTENNA IS STEERED

PART 1:

1. PHI=2*PI*(d/l)*SIN(TH0)= .90922 rad OR 52.0945 Deg. : PHASE DIFFERENCE BETWEEN TWO ARRAY ELEMENTS

PART 2:

2. B.W=K*1/(N*d1*COS(TH0))= 7.27746E-03 rad OR .416968 Deg. : BEAMWIDTH AT 10 Deg. FOR THE SAME OUTPUT OF ARRAY ELEMENT

```
10   PRINT : PRINT TAB(30) " PROBLEM #11 "
20   PRINT TAB(30); " -----------"
30   GOSUB 100 : GOSUB 840
40   GOSUB 1210
50   PRINT : PRINT " DO YOU WANT TO TRY AGAIN FOR DIFFERENT OR THE SAME DATA Y/N?"
60   INPUT D$
70   IF LEFT$(D$,1)="Y" OR LEFT$(D$,1)="y"  THEN 30
80   END
90   '*********************************
100  '          INPUTS THE DATA
110  '*********************************
120  PRINT : PRINT " ENTER THE ANTENNA GAIN Ga IN dbi"
130  INPUT Ga : PRINT : PRINT " 1. Ga=";Ga;"db"
140  PRINT : PRINT " ENTER THE PEAK POWER Pt IN Mw"
150  INPUT Pt : PRINT : PRINT " 2. Pt=";Pt;"Mw"
160  PRINT : PRINT " ENTER THE OPERATING FREQ. fo IN MHz"
170  INPUT fo : PRINT : PRINT " 3. fo=";fo;"MHz"
180  PRINT : PRINT " ENTER THE AMBIENT TEMPERATURE Ta IN KELVIN"
190  INPUT Ta : PRINT : PRINT " 4. Ta=";Ta;"KELVIN"
200  PRINT : PRINT " ENTER THE RECEIVER BANDWIDTH Bn IN MHz"
210  INPUT Bn : PRINT : PRINT " 5. Bn=";Bn;"MHz"
220  PRINT : PRINT " ENTER THE TARGET RADAR CROSS SECTION S IN sq.m"
230  INPUT S : PRINT : PRINT " 6. S=";S;"sq.m"
240  PRINT : PRINT " ENTER THE RECEIVER NOISE FIGURE F IN db"
250  INPUT F : PRINT : PRINT " 7. F=";F;"db"
260  PRINT : PRINT " ENTER THE P.R.F fp IN Hz"
270  INPUT fp : PRINT : PRINT " 8. fp=";fp;"Hz"
280  PRINT : PRINT " ENTER THE PULSE LENGTH t IN microsec."
290  INPUT t : PRINT : PRINT " 9. t=";t;"microsec."
300  PRINT : PRINT " ENTER THE INTEGRATION IMR. FACTOR I1(n) IN db"
310  INPUT I1 : PRINT : PRINT " 10. I1(n)=";I1;"db"
320  PRINT : PRINT " ENTER THE PROBABILITY OF DETECTION Pd"
330  INPUT Pd : PRINT : PRINT " 11. Pd=";Pd
340  PRINT : PRINT " ENTER THE FALSE ALARM RATE Pfa"
350  INPUT Pfa : PRINT : PRINT " 12. Pfa=";Pfa
```

```
360  PRINT : PRINT " ENTER THE SYSTEM LOSSES Ls IN db"
370  INPUT Ls : PRINT : PRINT " 13. Ls=";Ls;"db"
380  PRINT : PRINT " IS THE INPUT DATA CORRECT Y/N?"
390  INPUT A$
400  IF LEFT$(A$,1)="Y" OR LEFT$(A$,1)="y" THEN 820
410  PRINT : PRINT " WHAT OF THE FOLLOWING DO YOU WANT TO CHANGE?"
420  PRINT : PRINT " 1. THE ANTENNA GAIN?"," 2. THE PEAK POWER?"
430  PRINT : PRINT " 3. THE OPERATING FREQ.?"," 4. THE AMBIENT TEMPERATURE?"
440  PRINT : PRINT " 5. THE RECEIVER BANDWIDTH?"," 6. THE TARGET CROSS SECTION?"
450  PRINT : PRINT " 7. THE RECEIVER NOISE FIGURE?"," 8. THE P.R.F?"
460  PRINT : PRINT " 9. THE PULSE LENGTH?"," 10. THE INTEGRATION IMR. FACTOR?"
470  PRINT : PRINT " 11. THE PROBABILITY OF DETECTION?"," 12. THE FALSE ALARM RATE?"
480  PRINT : PRINT " 13. THE SYSTEM LOSSES?"
490  INPUT C$
500  IF C$="1"  THEN PRINT : PRINT " ENTER THE ANTENNA GAIN Ga IN dbi"
510  IF C$="1"  THEN INPUT Ga : PRINT : PRINT " 1. Ga=";Ga;"db" : GOTO 760
520  IF C$="2"  THEN PRINT : PRINT " ENTER THE PEAK POWER Pt IN Mw"
530  IF C$="2"  THEN INPUT Pt : PRINT : PRINT " 2. Pt=";Pt;"Mw" : GOTO 760
540  IF C$="3"  THEN PRINT : PRINT " ENTER THE OPERATING FREQ. fo IN MHz"
550  IF C$="3"  THEN INPUT fo : PRINT : PRINT " 3. fo=";fo;"MHz" : GOTO 760
560  IF C$="4"  THEN PRINT : PRINT " ENTER THE AMBIENT TEMPERATURE Ta IN KELVIN"
570  IF C$="4"  THEN INPUT Ta : PRINT : PRINT " 4. Ta=";Ta;"KELVIN" : GOTO 760
580  IF C$="5"  THEN PRINT : PRINT " ENTER THE RECEIVER BANDWIDTH Bn IN MHz"
590  IF C$="5"  THEN INPUT Bn : PRINT : PRINT " 5. Bn=";Bn;"MHz" : GOTO 760
600  IF C$="6"  THEN PRINT : PRINT " ENTER THE T \RGET RADAR CROSS SECTION S IN sq.m"
610  IF C$="6"  THEN INPUT S : PRINT : PRINT " 6. S=";S;"sq.m" : GOTO 760
620  IF C$="7"  THEN PRINT : PRINT " ENTER THE RECEIVER NOISE FIGURE F IN db"
630  IF C$="7"  THEN INPUT F : PRINT : PRINT " 7. F=";F;"db" : GOTO 760
640  IF C$="8"  THEN PRINT : PRINT " ENTER THE P.R.F fp IN Hz"
650  IF C$="8"  THEN INPUT fp : PRINT : PRINT " 8. fp=";fp;"Hz" : GOTO 760
660  IF C$="9"  THEN PRINT : PRINT " ENTER THE PULSE LENGTH t IN microsec."
670  IF C$="9"  THEN INPUT t : PRINT : PRINT " 9. t=";t;"microsec." : GOTO 760
680  IF C$="10"  THEN PRINT : PRINT " ENTER THE INTEGRATION IMR. FACTOR Ii(n) IN db"
690  IF C$="10"  THEN INPUT Ii : PRINT : PRINT " 10. Ii(n)=";Ii;"db" : GOTO 760
700  IF C$="11"  THEN PRINT : PRINT " ENTER THE PROBABILITY OF DETECTION Pd"
```

```
710  IF C$="11"  THEN INPUT Pd : PRINT : PRINT " 11. Pd=";Pd : GOTO 760
720  IF C$="12"  THEN PRINT : PRINT " ENTER THE FALSE ALARM RATE Pfa"
730  IF C$="12"  THEN INPUT Pfa : PRINT : PRINT " 12. Pfa=";Pfa : GOTO 760
740  IF C$="13"  THEN PRINT : PRINT " ENTER THE SYSTEM LOSSES Ls IN db"
750  IF C$="13"  THEN INPUT Ls : PRINT : PRINT " 13. Ls=";Ls;"db" : GOTO 760
760  PRINT : PRINT " IS EVERYTHING O.K NOW?"
770  INPUT B$
780  IF LEFT$(B$,1)="Y" OR LEFT$(B$,1)="y" THEN GOTO 820
790  PRINT : PRINT " WHAT DO YOU WANT TO CHANGE AGAIN?"
800  PRINT : PRINT " HIT ANY KEY IN YOUR KEYBOARD AND EVERYTHING WILL WORK FOR YOU
 MALAKA"
810  INPUT F$  : GOTO 410
820  RETURN
830 '*********************************
840 '       PRINTS THE INPUT DATA
850 '*********************************
860  LPRINT : LPRINT TAB(30);" PROBLEM #11"
870  LPRINT TAB(30);" -----------"
880  LPRINT : LPRINT " G I V E N"
890  LPRINT " ---------"
900  PRINT : PRINT " G I V E N"
910  PRINT " ---------"
920  PRINT : PRINT " 1. Ga=";Ga;"db" SPC(9); " : ANTENNA GAIN"
930  LPRINT : LPRINT " 1. Ga=";Ga;"db" SPC(9); " : ANTENNA GAIN"
940  PRINT : PRINT " 2. Pt=";Pt;"Mw" SPC(10); " : PEAK POWER"
950  LPRINT : LPRINT " 2. Pt=";Pt;"Mw" SPC(10); " : PEAK POWER"
960  PRINT : PRINT " 3. fo=";fo;"MHz" SPC(7); " : OPERATING FREQ."
970  LPRINT : LPRINT " 3. fo=";fo;"MHz" SPC(7); " : OPERATING FREQ."
980  PRINT : PRINT " 4. Ta=";Ta;"KELVIN" SPC(5); " : AMBIENT FREQ."
990  LPRINT : LPRINT " 4. Ta=";Ta;"KELVIN" SPC(5); " : AMBIENT FREQ."
1000 PRINT : PRINT " 5. Bn=";Bn;"MHz" SPC(9); " : RECEIVER BANDWIDTH"
1010 LPRINT : LPRINT " 5. Bn=";Bn;"MHz" SPC(9); " : RECEIVER BANDWIDTH"
1020 PRINT : PRINT " 6. S=";S;"sq.m" SPC(9); " : TARGET RADAR CROSS SECTION"
1030 LPRINT : LPRINT " 6. S=";S;"sq.m" SPC(9); " : TARGET RADAR CROSS SECTION"
1040 PRINT : PRINT " 7. F=";F;"db" SPC(10); " : RECEIVER NOISE FIGURE"
```

```
1050 LPRINT : LPRINT " 7. F=";F;"db" SPC(10); " : RECEIVER NOISE FIGURE"
1060 PRINT : PRINT " 8. fp=";fp;"Hz" SPC(8); " : P.R.F"
1070 LPRINT : LPRINT " 8. fp=";fp;"Hz" SPC(8); " : P.R.F"
1080 PRINT : PRINT " 9. t=";t;"microsec." SPC(4); " : PULSE LENGTH"
1090 LPRINT : LPRINT " 9. t=";t;"microsec." SPC(4); " : PULSE LENGTH"
1100 PRINT : PRINT " 10. Il(n)=";Il;"db" SPC(3); " : INTEGRATION IMR. FACTOR"
1110 LPRINT : LPRINT " 10. Il(n)=";Il;"db" SPC(3); " : INTEGRATION IMR. FACTOR"
1120 PRINT : PRINT " 11. Pd=";Pd SPC(10); " : PROBABILITY OF DETECTION"
1130 LPRINT : LPRINT " 11. Pd=";Pd SPC(10); " : PROBABILITY OF DETECTION"
1140 PRINT : PRINT " 12. Pfa=";Pfa; ": FALSE ALARM RATE"
1150 LPRINT : LPRINT " 12. Pfa=";Pfa; ": FALSE ALARM RATE"
1160 PRINT : PRINT " 13. Ls=";Ls;"db" SPC(9); " : SYSTEM LOSSES"
1180 LPRINT : LPRINT " 13. Ls=";Ls;"db" SPC(9); " : SYSTEM LOSSES"
1190 RETURN
1200'***********************************
1210 '  CALCULATION & PRINTOUT
1220'***********************************
1230 PRINT : PRINT : PRINT " OUTPUT"
1240 PRINT " ------"
1250 LPRINT : LPRINT : LPRINT " OUTPUT"
1260 LPRINT " ------"
1270 LET C=3*10^8
1280 LET fo=fo*10^6
1290 LET l=C/fo
1300 LET K=1.38*10^-23
1310 LET T=290
1320 LET PI=3.14159
1330 LET Pt=Pt*10^6
1340 LET Bn=Bn*10^6
1350 LET M=.4342945#
1360 PRINT : PRINT " FROM Fig. 2.7 (Skolnik Pg. 28) YOU CAN FIND THE (S/N) I SINCE YOU KNOW
 :"
1370 PRINT : PRINT " Pd=";Pd, "&","Pfa=";Pfa
1380 PRINT : PRINT " ENTER THE (S/N) I SN IN db"
1390 INPUT SN
```

```
1400 LET Pt=10*M*LOG(Pt) : l=10*M*LOG(l) : S=10*M*LOG(S)
1410 LET SUM1=Pt+2*Ge+2*l+Il+S
1420 LET  Bn=10*M*LOG(Bn)
1430 LET A=(4*PI)^3 : A=10*M*LOG(A)
1440 LET B=K*T : B=10*M*LOG(B)
1450 LET SUM2=A+B+Bn+F+SN+Ls
1460 LET Rmax=(SUM1-SUM2)/4 : Rmax=Rmax/10 : Rmax=10^Rmax
1470 PRINT : PRINT : PRINT " Rmax=";CSNG(Rmax/1000);"Km"; " or";
 CSNG(Rmax/(1000*1.85));" n. miles";"  :MAX. RADAR RANGE"
1480 LPRINT : LPRINT : LPRINT " Rmax=";CSNG(Rmax/1000);"Km"; " or";
 CSNG(Rmax/(1000*1.85));" n.miles"; "  :MAX. RADAR RANGE"
1490 RETURN
```

PROBLEM # 11

GIVEN

1. Ga= 21 db : ANTENNA GAIN
2. Pt= 2 Mw : PEAK POWER
3. fo= 500 MHz : OPERATING FREQ.
4. Te= 62 KELVIN : AMBIENT FREQ.
5. Bn= 1 MHz : RECEIVER BANDWIDTH
6. S= 5 sq.m : TARGET RADAR CROSS SECTION
7. F= 10 db : RECEIVER NOISE FIGURE
8. fp= 300 Hz : P.R.F
9. t= 3 microsec. : PULSE LENGTH
10. Ii(n)= 16.5 db : INTEGRATION IMR. FACTOR
11. Pd= .9 : PROBABILITY OF DETECTION
12. Pfa= .1E-12 : FALSE ALARM RATE
13. Ls= 6 db : SYSTEM LOSSES

OUTPUT

Rmax= 123.481 Km or 66.7464 n. miles : MAX. RADAR RANGE

```
10    PRINT : PRINT TAB(30) " PROBLEM #12 "
20    PRINT TAB(30); " ----------"
30    GOSUB 100  : GOSUB 1040 : GOSUB 1380 : GOSUB 1490
40    GOSUB 1690 : GOSUB 1840 : GOSUB 1950 : GOSUB 2110
50    PRINT : PRINT " DO YOU WANT TO TRY AGAIN FOR DIFFERENT OR THE SAME DATA Y/N?"
60    INPUT D$
70    IF LEFT$(D$,1)="Y" OR LEFT$(D$,1)="y"  THEN 20
80    END
90    '**********************************
100   '          INPUTS THE DATA
110   '**********************************
120   PRINT : PRINT " ENTER THE OPERATING FREQ. fo IN MHz"
130   INPUT fo : PRINT : PRINT "  1. fo=";fo;"MHz"
140   PRINT : PRINT " ENTER THE PEAK POWER Pt IN KW"
150   INPUT Pt : PRINT : PRINT " 2. Pt=";Pt;"KW"
160   PRINT : PRINT " ENTER THE P.R.F fp IN Hz"
170   INPUT fp : PRINT : PRINT " 3. fp=";fp;"Hz"
180   PRINT : PRINT " ENTER THE PULSE WIDTH t IN microsec."
190   INPUT t : PRINT : PRINT " 4. t=";t;"microsec."
200   PRINT : PRINT " ENTER THE ANTENNA SCAN RATE Wm IN Hz"
210   INPUT Wm : PRINT : PRINT " 5. Wm=";Wm;"Hz"
220   PRINT : PRINT " ENTER THE AZIMUTH BEAMWIDTH A.B IN deg."
230   INPUT A.B : PRINT : PRINT " 6. A.B=";A.B;"deg."
240   PRINT : PRINT " ENTER THE ANTENNA GAIN Ga IN db"
250   INPUT Ga : PRINT : PRINT " 7. Ga=";Ga;"db"
260   PRINT : PRINT " ENTER THE RECEIVER NOISE BANDWIDTH Bn IN MHz"
270   INPUT Bn : PRINT : PRINT " 8. Bn=";Bn;"MHz"
280   PRINT : PRINT " ENTER THE RECEIVER NOISE FIGURE F IN db"
290   INPUT F : PRINT : PRINT " 9. F=";F;"db"
300   PRINT : PRINT " ENTER THE SYSTEM LOSSES Ls IN db"
310   INPUT Ls : PRINT : PRINT " 10. Ls=";Ls;"db"
320   PRINT : PRINT " ENTER THE FALSE ALARM TIME Tfa IN days"
330   INPUT Tfa : PRINT : PRINT " 11. Tfa=";Tfa;"days"
340   PRINT : PRINT " ENTER THE ANTENNA NOISE TEMPERATURE Ta IN KELVIN"
350   INPUT Ta : PRINT : PRINT " 12. Ta=";Ta;"Kelvin"
```

```
420  PRINT : PRINT " IS THE INPUT DATA CORRECT Y/N?"
430  INPUT A$
440  IF LEFT$(A$,1)="Y" OR LEFT$(A$,1)="y" THEN 1020
450  PRINT : PRINT " WHAT OF THE FOLLOWING DO YOU WANT TO CHANGE?"
460  PRINT : PRINT " 1. THE OPERATING FREQ.?"
470  PRINT : PRINT " 2. THE PEAK POWER?"
480  PRINT : PRINT " 3. THE P.R.F?"
490  PRINT : PRINT " 4. THE PULSE WIDTH?"
500  PRINT : PRINT " 5. THE ANTENNA SCAN RATE?"
510  PRINT : PRINT " 6. THE AZIMUTH BEAMWIDTH?"
520  PRINT : PRINT " 7. THE ANTENNA GAIN?"
530  PRINT : PRINT " 8. THE RECEIVER NOISE BANDWIDTH?"
540  PRINT : PRINT " 9. THE RECEIVER NOISE FIGURE?"
550  PRINT : PRINT " 10. THE SYSTEM LOSSES?"
560  PRINT : PRINT " 11. THE FALSE ALARM TIME?"
570  PRINT : PRINT " 12. THE ANTENNA NOISE TEMPERATURE?"
580  INPUT C$
590  IF C$="1" THEN PRINT : PRINT " ENTER THE OPERATING FREQ. fo IN MHz"
600  IF C$="1" THEN INPUT fo : PRINT : PRINT " 1. fo=";fo;"MHz" : GOTO 820
610  IF C$="2" THEN PRINT : PRINT " ENTER THE PEAK POWER Pt IN KW"
620  IF C$="2" THEN INPUT Pt : PRINT : PRINT " 2. Pt=";Pt;"KW" : GOTO 820
630  IF C$="3" THEN PRINT : PRINT " ENTER THE P.R.F fp IN Hz"
640  IF C$="3" THEN INPUT fp : PRINT : PRINT " 3. fp=";fp;"Hz" : GOTO 820
650  IF C$="4" THEN PRINT : PRINT " ENTER THE PULSE WIDTH t IN microsec."
660  IF C$="4" THEN INPUT t : PRINT : PRINT " 4. t=";t;"microsec." : GOTO 820
670  IF C$="5" THEN PRINT : PRINT " ENTER THE ANTENNA SCAN RATE Wm IN Hz"
680  IF C$="5" THEN INPUT Wm : PRINT : PRINT " 5. Wm=";Wm;"Hz" : GOTO 820
690  IF C$="6" THEN PRINT : PRINT " ENTER THE AZIMUTH BEAMWIDTH A.B IN deg."
700  IF C$="6" THEN INPUT A.B : PRINT : PRINT " 6. A.B=";A.B;"deg." : GOTO 820
710  IF C$="7" THEN PRINT : PRINT " ENTER THE ANTENNA GAIN Ga IN db"
720  IF C$="7" THEN INPUT Ga : PRINT : PRINT " 7. Ga=";Ga;"db" : GOTO 820
730  IF C$="8" THEN PRINT : PRINT " ENTER THE RECEIVER NOISE BANDWIDTH Bn IN MHz"
740  IF C$="8" THEN INPUT Bn : PRINT : PRINT " 8. Bn=";Bn;"MHz" : GOTO 820
750  IF C$="9" THEN PRINT : PRINT " ENTER THE RECEIVER NOISE FIGURE F IN db"
760  IF C$="9" THEN INPUT F : PRINT : PRINT " 9. F=";F;"db" : GOTO 820
```

```
770  IF C$="10"  THEN PRINT : PRINT " ENTER THE SYSTEM LOSSES Ls IN db"
780  IF C$="10"  THEN INPUT Ls : PRINT : PRINT " 10. Ls=";Ls;"db" : GOTO 820
780  IF C$="11"  THEN PRINT : PRINT " ENTER THE FALSE ALARM TIME Tfa IN days"
790  IF C$="11"  THEN INPUT Tfa : PRINT : PRINT " 11. Tfa=";Tfa;"days" : GOTO 820
800  IF C$="12"  THEN PRINT : PRINT " ENTER THE ANTENNA NOISE TEMPERATURE Ta IN
 KELVIN"
810  IF C$="12"  THEN INPUT Ta : PRINT : PRINT " 12. Ta=";Ta;"Kelvin" : GOTO 820
820  PRINT : PRINT " IS EVERYTHING O.K NOW?"
970  INPUT B$
980  IF LEFT$(B$,1)="Y" OR LEFT$(B$,1)="y" THEN GOTO 1020
990  PRINT : PRINT " WHAT DO YOU WANT TO CHANGE AGAIN?"
1000 PRINT : PRINT "HIT ANY KEY IN YOUR KEYBOARD AND EVERYTHING WILL WORK FOR YOU
 MALAKA"
1010 INPUT F$  : GOTO 460
1020 RETURN
1030'**********************************
1040 '      PRINTS THE INPUT DATA
1050'**********************************
1060 LPRINT : LPRINT TAB(30); " PROBLEM #12"
1070 LPRINT TAB(30); " ------------"
1080 LPRINT : LPRINT " G I V E N"
1090 LPRINT " ---------"
1100 PRINT : PRINT " G I V E N"
1110 PRINT " ---------"
1120 PRINT : PRINT " 1. fo=";fo;"MHz" SPC(7); " : OPERATING FREQ."
1130 LPRINT : LPRINT " 1. fo=";fo;"MHz" SPC(7); " : OPERATING FREQ."
1140 PRINT : PRINT " 2. Pt=";Pt;"KW" SPC(9); " : PEAK POWER"
1150 LPRINT : LPRINT " 2. Pt=";Pt;"KW" SPC(9); " : PEAK POWER"
1160 PRINT : PRINT " 3. fp=";fp;"Hz" SPC(9) " : P.R.F"
1170 LPRINT : LPRINT " 3. fp=";fp;"Hz" SPC(9) " : P.R.F"
1180 PRINT : PRINT " 4. t=";t;"microsec" SPC(4); " : PULSE WIDTH"
1190 LPRINT : LPRINT " 4. t=";t;"microsec" SPC(4); " : PULSE WIDTH"
1200 PRINT : PRINT " 5. Wm=";Wm;"Hz" SPC(10); " : ANTENNA SCAN RATE"
1210 LPRINT : LPRINT " 5. Wm=";Wm;"Hz" SPC(10); " : ANTENNA SCAN RATE"
1220 PRINT : PRINT " 6. A.B=";A.B;"deg." SPC(6); " : AZIMUTH BEAMWIDTH"
```

```
1230 LPRINT : LPRINT " 6. A.B=";A.B;"deg." SPC(6); " : AZIMUTH BEAMWIDTH"
1240 PRINT : PRINT " 7. Ga=";Ga;"db" SPC(10); " : ANTENNA GAIN"
1250 LPRINT : LPRINT " 7. Ga=";Ga;"db" SPC(10); " : ANTENNA GAIN"
1260 PRINT : PRINT " 8. Bn=";Bn;"MHZ" SPC(10); " : RECEIVER NOISE BANDWIDTH"
1270 LPRINT : LPRINT " 8. Bn=";Bn;"MHZ" SPC(10); " : RECEIVER NOISE BANDWIDTH"
1280 PRINT : PRINT " 9. F=";F;"db"; SPC(9); " : RECEIVER NOISE FIGURE"
1290 LPRINT : LPRINT " 9. F=";F;"db"; SPC(9); " : RECEIVER NOISE FIGURE"
1300 PRINT : PRINT " 10. Ls=";Ls;"db" SPC(10); " : SYSTEM LOSSES"
1310 LPRINT : LPRINT " 10. Ls=";Ls;"db" SPC(10); " : SYSTEM LOSSES"
1320 PRINT : PRINT " 11. Tfa=";Tfa SPC(11);" : FALSE ALARM TIME"
1330 LPRINT : LPRINT " 11. Tfa=";Tfa SPC(11);" : FALSE ALARM TIME"
1340 PRINT : PRINT " 12. Ta=";Ta;"Kelvin" SPC(5); " : ANTENNA NOISE TEMPERATURE"
1350 LPRINT : LPRINT " 12. Ta=";Ta;"Kelvin" SPC(5); " : ANTENNA NOISE TEMPERATURE"
1360 RETURN
1370'**************************************
1380 ' CALCULATION & PRINTOUT FOR PART a:
1390'**************************************
1400 PRINT : PRINT : PRINT " PART a:"
1410 PRINT " -------"
1420 LPRINT : LPRINT : LPRINT " PART a:"
1430 LPRINT " -------"
1440 LET Ts=60/Wm : n=CSNG(A.B*Ts*fp/360)
1450 PRINT : PRINT " n=";n; " : # OF HITS PER SCAN"
1460 LPRINT : LPRINT " n=";n; " : # OF HITS PER SCAN"
1470 RETURN
1480'**************************************
1490 ' CALCULATION & PRINTOUT FOR PART b:
1500'**************************************
1510 PRINT : PRINT : PRINT " PART b:"
1520 PRINT " -------"
1530 LPRINT : LPRINT : LPRINT " PART b:"
1540 LPRINT " -------"
1550 LET Tfa=Tfa*24*3600 : Bn=Bn*10^6 : Pfa=CSNG(1/(Tfa*Bn))
1560 PRINT : PRINT " ENTER THE PROBABILITY OF DETECTION Pd"
1570 INPUT Pd
```

```
1580 PRINT : PRINT " FROM FIG. 2.7 (Skolnik Pg. 28) YOU CAN FIND THE (S/N)1 SINCE THE :"
1590 PRINT : PRINT " Pfa=";Pfa,"&","Pd=";Pd
1600 INPUT SN
1610 PRINT : PRINT " a. Pd=";Pd;" : PROBABILITY OF DETECTION"
1620 PRINT : PRINT " b. Pfa=";Pfa;" : PROBABILITY OF FALSE ALARM"
1630 PRINT : PRINT " c. (S/N)1=";SN;"db";" : (S/N) FOR SINGLE PULSE"
1640 LPRINT :LPRINT " a. Pd=";Pd;" : PROBABILITY OF DETECTION"
1650 LPRINT : LPRINT " b. Pfa=";Pfa;" : PROBABILITY OF FALSE ALARM"
1660 LPRINT : LPRINT "c. (S/N)1=";SN;"db";" : (S/N) FOR SINGLE PULSE"
1670 RETURN
1680'*************************************
1690 ' CALCULATION & PRINTOUT FOR PART c:
1700'*************************************
1710 PRINT : PRINT : PRINT " PART c:"
1720 PRINT "-------"
1730 LPRINT : LPRINT : LPRINT " PART c:"
1740 LPRINT "-------"
1750 PRINT : PRINT "FROM Fig. 2.8(a), (Skolnik Pg. 31) YOU CAN FIND THE INTEGRATION
 IMROVEMENT"
1760 PRINT :PRINT " FOR INCOHERENT INTEGRATION OF n=";"n";"PULSES"
1770 PRINT : PRINT " ENTER THE INTEGRATION IMR. I1(n)"
1780 INPUT I1
1790 I11=CSNG(10*.4342945#*LOG(I1))
1800 PRINT : PRINT " I1(n)=";I1;"numeric";" or";I11;"db"
1810 LPRINT :LPRINT "I1(n)=";I1;"numeric";" or";I11;"db"
1820 RETURN
1830'*************************************
1840 ' CALCULATION & PRINTOUT FOR PART d:
1850'*************************************
1860 PRINT : PRINT : PRINT " PART d:"
1870 PRINT "-------"
1880 LPRINT : LPRINT : LPRINT " PART d:"
1881 LPRINT "-------"
1890 LET K=1.38*10^-23 T0=290: F=F/10 : F=10^F
1900 LET MDS=K*T0*F*Bn MDS1-CSNG(10* 4342945#*LOG(MDS))
```

```
1910 PRINT :PRINT "M.D.S=";MDS1;"dbw"; " : MINIMUM DETECTABLE SIGNAL POWER"
1920 LPRINT :LPRINT "M.D.S=";MDS1;"dbw"; " : MINIMUM DETECTABLE SIGNAL POWER"
1930 RETURN
1940'************************************
1950 ' CALCULATION & PRINTOUT FOR PART e & f:
1960'************************************
1970 PRINT : PRINT : PRINT " PART e & f:"
1980 PRINT "-----------"
1990 LPRINT : LPRINT : LPRINT " PART e & f:"
1991 LPRINT "-----------"
2000 LET Pt=Pt*10^3:Pt1=CINT(10*.4342945#*LOG(Pt))
2010 LET Peff=Pt1+Ga
2020 LET PI=3.14159: Ga=Ga/10:Ga=10^Ga
2030 LET C=3*10^8 : fo=fo*10^6 : l=C/fo
2040 LET Ae=CSNG(l^2*Ga/(4*PI))
2050 PRINT : PRINT "e. Peff=";Peff;"dbw"; " : PEAK EFFECTIVE RADIATED POWER"
2060 PRINT : PRINT " f. Ae=";Ae;"sq.m"; " : EEFFECTIVE AREA OF THE ANTENNA "
2070 LPRINT : LPRINT "e. Peff=";Peff;"dbw"; " : PEAK EFFECTIVE RADIATED POWER"
2080 LPRINT : LPRINT " f. Ae=";Ae;"sq.m"; " : EEFFECTIVE AREA OF THE ANTENNA "
2090 RETURN
2100'************************************
2110 ' CALCULATION & PRINTOUT FOR PART g:
2130'************************************
2140 PRINT : PRINT : PRINT " PART g:"
2150 PRINT "-------"
2160 LPRINT : LPRINT : LPRINT " PART g:"
2161 LPRINT "-------"
2170 PRINT : PRINT "ENTER THE CROSS SECTION OF THE NON FLUCTUATING TARGET RCS IN db"
2180 INPUT RCS
2190 LET Ls=Ls/10 :Ls-10^Ls :Te-(F 1)*TO :RCS=RCS/10 :RCS=10^-RCS
2200 LET SN=SN/10 : SN=10^SN
2210LETRmax=CSNG((Pt*Ga*Ae*RCS*l1/((4*PI)^2*K*(Ta+Te)*Bn*SN*Ls))^(1/4))
2220 PRINT : PRINT " Rmax=";Rmax/1000;"KM"; " : MAXIMUM RANGE"
2230 LPRINT : LPRINT " Rmax=";Rmax/1000;"KM"; " :MAXIMUM RANGE"
2240 RETURN
```

PROBLEM # 12

GIVEN

1. fo= 5600 MHz : OPERATING FREQ.
2. Pt= 200 KW : PEAK POWER
3. fp= 625 Hz : P.R.F
4. t= 1.4 microsec : PULSE WIDTH
5. Wm= 16 Hz : ANTENNA SCAN RATE
6. A.B= 1.5 deg. : AZIMUTH BEAMWIDTH
7. Ga= 33 db : ANTENNA GAIN
8. Bn= 1 MHZ : RECEIVER NOISE BANDWIDTH
9. F= 9.88 db : RECEIVER NOISE FIGURE
10. Ls= 5 db : SYSTEM LOSSES
11. Tfa= 2 : FALSE ALARM TIME
12. Ta= 75 Kelvin : ANTENNA NOISE TEMPERATURE

PART a:

n= 9.76563 : # OF HITS PER SCAN

PART b:

a. Pd= .95 : PROBABILITY OF DETECTION
b. Pfa= 5.78704D-12 : PROBABILITY OF FALSE ALARM
c. (S/N)1= 16 db : (S/N) FOR SINGLE PULSE

PART c:

Ii(n)= 7 numeric or 8.45098 db

PART d:

M.D.S=-134.097 dbw : MINIMUM DETECTABLE SIGNAL POWER

PART e & f:

e. Peff= 86 dbw : PEAK EFFECTIVE RADIATED POWER

PART g:

Rmax= 36.5283 KM: MAXIMUM RANGE

```
10   PRINT : PRINT TAB(30); " PROBLEM # 13 "
20   PRINT TAB(30); " -----------"
30   GOSUB 100   : GOSUB 710  : GOSUB 990
40   GOSUB 1110 : GOSUB 1240 : GOSUB 1350
50   PRINT : PRINT " DO YOU WANT TO TRY AGAIN FOR DIFFERENT OR THE SAME DATA Y/N?"
60    INPUT D$
70   IF LEFT$(D$,1)="Y" OR LEFT$(D$,1)="y"   THEN 30
80    END
90  '*********************************
100  '           INPUTS THE DATA
110  '*********************************
120  PRINT : PRINT " ENTER THE OPERATING FREQ. fo IN GHz"
130   INPUT fo : PRINT : PRINT " 1. fo=";fo;"GHz"
140  PRINT : PRINT "ENTER THE RADAR CROSS SECTION OF THE VEHICLES RCS IN dbsm"
150  INPUT RCS : PRINT : PRINT " 2. RCS=";RCS;"dbsm"
160  PRINT : PRINT " ENTER THE TRAVELING SPEED OF THE VEHICLES U IN mi/hrs"
170  INPUT U : PRINT : PRINT " 3. U=";U;"mi/hrs"
180  PRINT : PRINT " ENTER THE RANGE THE RADAR WILL DETECT THE VEHICLES R IN MILES"
190   INPUT R : PRINT : PRINT " 4. R=";R;"miles"
200  PRINT :PRINT " ENTER THE (S/N) REQUIRED AT THE OUTPUT OF THE IF AMPLIFIER SNout IN
 db"
210  INPUT SNout : PRINT : PRINT " 5. (S/N)out=";SNout;"db"
220  PRINT : PRINT " ENTER THE RECEIVER NOISE FIGURE F IN db"
230   INPUT F : PRINT : PRINT " 6. F=";F;"db"
240  PRINT : PRINT " ENTER THE PLUMBING LOSSES Lp IN db"
250   INPUT Lp : PRINT : PRINT " 7. Lp=";Lp;"db"
260  PRINT : PRINT " ENTER THE NOISE TEMPERATURE OF THE RECEIVER Te IN KELVIN"
270  INPUT Te : PRINT : PRINT " 8. Te=";Te;"Kelvin"
280  PRINT : PRINT " ENTER THE GAIN Gt OF THE TRANSMIT ANTENNA & Gr OF THE RECEIVE
 ANTENNA IN db"
290  INPUT Gr,Gt : PRINT : PRINT " 9. Gt=";Gt, "Gr=";Gr;"db"
300  PRINT : PRINT " IS THE INPUT DATA CORRECT Y/N?"
310   INPUT A$
320  IF LEFT$(A$,1)="Y" OR LEFT$(A$,1)="y" THEN 690
330  PRINT : PRINT " WHAT OF THE FOLLOWING DO YOU WANT TO CHANGE?"
```

```
340 PRINT : PRINT " 1. THE OPERATING FREQ.?"
350 PRINT : PRINT "2. THE VEHICLES RADAR CROSSS SECTION?"
360 PRINT : PRINT " 3. THE VELOCITY OF THE VEHICLES?"
370 PRINT : PRINT " 4. THE RANGE OF THE VEHICLES?"
380 PRINT : PRINT " 5. THE (S/N) AT THE OUTPUT OF THE RECEIVER?"
390 PRINT : PRINT " 6. THE RECEIVER NOISE FIGURE?"
400 PRINT : PRINT " 7. THE PLUMBING LOSSES?"
410 PRINT : PRINT " 8. THE AMIENT TEMPERATURE?"
420 PRINT : PRINT " 9. THE GAIN OF THE TRNSMIT & RECEIVE ANTENNA?"
430 INPUT C$
440 IF C$="1" THEN PRINT : PRINT " ENTER THE OPERATING FREQ. fo IN GHz"
450 IF C$="1" THEN INPUT fo : PRINT : PRINT " 1. fo=";fo;"GHz" : GOTO 620
460 IF C$="2" THEN PRINT : PRINT " ENTER THE RADAR CROSS SECTION OF THE VEHICLES RCS
 INdbsm"
470 IF C$="2" THEN INPUT RCS : PRINT : PRINT " 2. RCS=";RCS;"dbsm" : GOTO 620
480 IF C$="3" THEN PRINT : PRINT " ENTER THE TRAVELING SPEED OF THE VEHICLES U IN
 mi/hrs"
490 IF C$="3" THEN INPUT U : PRINT : PRINT " 3. U=";U;"mi/hrs" : GOTO 620
500 IF C$="4" THEN PRINT : PRINT " ENTER THE RANGE THE RADAR WILL DETECT THE
 VEHICLES R IN MILES"
510 IF C$="4" THEN INPUT R : PRINT : PRINT " 4. R=";R;"miles" : GOTO 620
520 IF C$="5" THEN PRINT : PRINT " ENTER THE (S/N) REQUIRED AT THE OUTPUT OF THE IF
 AMPLIFIER SNout IN db"
530 IF C$="5" THEN INPUT SNout : PRINT : PRINT " 5. (S/N)out=";SNout;"db" : GOTO 620
540 IF C$="6" THEN PRINT : PRINT " ENTER THE RECEIVER NOISE FIGURE F IN db"
550 IF C$="6" THEN INPUT F : PRINT : PRINT " 6. F=";F;"db" : GOTO 620
560 IF C$="7" THEN PRINT : PRINT " ENTER THE PLUMBING LOSSES Lp IN db"
570 IF C$="7" THEN INPUT Lp : PRINT : PRINT " 7. Lp=";Lp;"db" : GOTO 620
580 IF C$="8" THEN PRINT : PRINT " ENTER THE NOISE TEMPERATURE OF THE RECEIVER Ta IN
 KELVIN"
590 IF C$="8" THEN INPUT Ta : PRINT : PRINT " 8. Ta=";Ta;"Kelvin" : GOTO 620
600 IF C$="9" THEN PRINT : PRINT " ENTER THE GAIN Gt OF THE TRANSMIT ANTENNA & Gr OF
 THE RECEIVE ANTENNA IN db"
610 IF C$="9" THEN INPUT Gr,Gt : PRINT : PRINT " 9. Gt=";Gt, "Gr=";Gr;"db" . GOTO 620
620 PRINT : PRINT " IS EVERYTHING O.K NOW?"
```

```
630  INPUT B$
640  IF LEFT$(B$,1)="Y" OR LEFT$(B$,1)="y" THEN GOTO 690
650  PRINT : PRINT " WHAT DO YOU WANT TO CHANGE AGAIN?"
670  PRINT : PRINT " HIT ANY KEY IN YOUR KEYBOARD AND EVERYTHING WILL WORK FOR YOU
MALAKA"
680  INPUT F$   : GOTO 340
690  RETURN
700  '*********************************
710  '      PRINTS THE INPUT DATA
720  '*********************************
730  LPRINT : LPRINT TAB(30); " PROBLEM #13"
740  LPRINT TAB(30); " -----------"
750  LPRINT : LPRINT " G I V E N"
760  LPRINT " ---------"
770  PRINT : PRINT " G I V E N"
780  PRINT " ---------"
790  PRINT : PRINT " 1. fo=";fo;"GHz" SPC(10); " : OPERATING FREQ."
800  LPRINT : LPRINT " 1. fo=";fo;"GHz" SPC(10); " : OPERATING FREQ."
810  PRINT : PRINT " 2. RCS=";RCS;"dbsm" SPC(9); " : VEHICLES RADAR CROSS SECTION"
820  LPRINT : LPRINT " 2. RCS=";RCS;"dbsm" SPC(9); " : VEHICLES RADAR CROSS SECTION"
830  PRINT : PRINT " 3. U=";U;"mi/hrs" SPC(7); " : VEHICLES'S TRAVELING VELOCITY"
840  LPRINT : LPRINT " 3. U=";U;"mi/hrs" SPC(7); " : VEHICLES'S TRAVELING VELOCITY"
850  PRINT : PRINT " 4. R=";R;"miles" SPC(9); " : RADAR-VEHICLE RANGE"
860  LPRINT : LPRINT " 4. R=";R;"miles" SPC(9); " : RADAR-VEHICLE RANGE"
870  PRINT : PRINT " 5. (S/N)out=";SNout;"db" SPC(5); " : SIGNAL-TO-NOISE RATIO AT THE
OUTPUT OF THERECEIVER"
880  LPRINT : LPRINT " 5. (S/N)out=";SNout;"db" SPC(5); " : SIGNAL-TO-NOISE RATIO AT THE
OUTPUT OF THERECEIVER"
890  PRINT : PRINT " 6. F=";F;"db" SPC(10); " : RECEIVER NOISE FIGURE"
900  LPRINT : LPRINT " 6. F=";F;"db" SPC(10); " : RECEIVER NOISE FIGURE"
910  PRINT : PRINT " 7. Lp=";Lp;"db" SPC(12); " : PLUMBING LOSSES"
920  LPRINT : LPRINT " 7. Lp=";Lp;"db" SPC(12); " : PLUMBING LOSSES"
930  PRINT : PRINT " 8. To=";To;"Kelvin" SPC(6); " : AMBIENT TEMPERATURE"
940  LPRINT : LPRINT " 8. To=";To;"Kelvin" SPC(6); " : AMBIENT TEMPERATURE"
950  PRINT : PRINT " 9. Gt=";Gt; " Gr=";Gr;" db" SPC(1); " : TRANSMIT & RECEIVE ANTENNAS
```

```
GAIN"
960  LPRINT : LPRINT " 9. Gt=";Gt; " Gr=";Gr;" db" SPC(1); " : TRANSMIT & RECEIVE ANTENNAS
GAIN"
970  RETURN
980 '***********************************
990  ' CALCULATION & PRINTOUT OF PART a:
1000'***********************************
1010 PRINT : PRINT : PRINT " PART a:"
1020 PRINT " -------:
1030 LPRINT : LPRINT : LPRINT " PART a:"
1040 LPRINT " -------:
1050 LET fo=fo*10^9 : U=U*.447 : R=R*1610 : C=3*10^8
1060 LET fd=2*u*fo/C : B=CINT(2*fd)
1070 PRINT : PRINT "B=";B/1000;"KHz"; " : RECEIVER BANDWIDTH"
1080 LPRINT : LPRINT " B=";B/1000;"KHz";" :RECEIVER BANDWIDTH"
1090 RETURN
1100'***********************************
1110 ' CALCULATION & PRINTOUT OF PART b:
1120'***********************************
1130 PRINT : PRINT : PRINT " PART b:"
1140 PRINT " -------:
1150 LPRINT : LPRINT : LPRINT " PART b:"
1160 LPRINT " -------:
1170 LET K=1.38*10^-23 : T0=290 : F=F/10 : F=10^F : Te=(F-1)*T0
1180 LET SNout=SNout/10 : SNout=10^SNout
1190 LET Sinp=K*(Ta+Te)*B*SNout : Sinp=CINT(10*.4342945**LOG(Sinp)+(Lp/2)+30)
1200 PRINT : PRINT "Sinp=";Sinp;"dbm"; " : RECEIVER INPUT SIGNAL POWER"
1210 LPRINT : LPRINT "Sinp=";Sinp;"dbm"; " : RECEIVER INPUT SIGNAL POWER"
1220 RETURN
1230'***********************************
1240 ' CALCULATION & PRINTOUT OF PART c:
1250'***********************************
1260 PRINT : PRINT : PRINT " PART c:"
1270 PRINT " -------:
1280 LPRINT : LPRINT : LPRINT " PART c:"
```

```
1290 LPRINT " -------:
1300 LET l=C/fo :PI=3.14159 :Lbf=CSNG(10*.4342945#*2*LOG(4*PI*R/l))
1310 PRINT : PRINT " Lbf=";Lbf;"db"; " : ONE WAY FREE SPACE LOSSES FOR TARGET VEHICLES AT
 ARANGE R=";R/1610;"miles"
1320 LPRINT : LPRINT " Lbf=";Lbf;"db"; " : ONE WAY FREE SPACE LOSSES FOR TARGET VEHICLES
 AT ARANGE R=";R/1610;"miles"
1330 RETURN
1340'*************************************
1350 ' CALCULATION & PRINTOUT OF PART d:
1360'*************************************
1370 PRINT : PRINT : PRINT " PART d:"
1380 PRINT " -------:
1390 LPRINT : LPRINT : LPRINT " PART d:"
1400 LPRINT " -------:
1410 LET RCS=RCS/10 : RCS=10^-RCS : Gs=10*.4342945#*LOG(4*PI*RCS/l^2)
1420 LET Pt=CSNG(Sinp-Gs+(2*Lbf-Gt-Gr)+(Lp/2))
1430 PRINT : PRINT " Pt=";. ·"dbm"; " : TRANSMITTER OUTPUT POWER"
1440 LPRINT : LPRINT " Pt=";Pt;"dbm"; " : TRANSMITTER OUTPUT POWER"
1450 RETURN
```

PROBLEM # 13

GIVEN

1. fo= 10 GHz : OPERATING FREQ.
2. RCS= 0 dbsm : VEHICLES RADAR CROSS SECTION
3. U= 100 mi/hrs : VEHICLES'S TRAVELING VELOCITY
4. R= .5 miles : RADAR-VEHICLE RANGE
5. (S/N)out= 15 db : SIGNAL-TO-NOISE RATIO AT THE OUTPUT OF THE RECEIVER
6. F= 7.25 db : RECEIVER NOISE FIGURE
7. Lp= 2 db : PLUMBING LOSSES
8. Te= 300 Kelvin : AMBIENT TEMPERATURE
9. Gt= 20 Gr= 20 db : TRANSMIT & RECEIVE ANTENNAS GAIN

PART a:

B= 5.96 KHz : RECEIVER BANDWIDTH

PART b:

Sinp=-113 dbm : RECEIVER INPUT SIGNAL POWER

PART c:

Lbf= 110.558 db : ONE WAY FREE SPACE LOSSES FOR TARGET VEHICLES AT A RANGE R= .5 miles

PART d:

Pt= 27.6663 dbm : TRANSMITTER OUTPUT POWER

```
10   PRINT : PRINT TAB(30); " PROBLEM # 14"
20   PRINT TAB(30); " -----------"
30   LPRINT : LPRINT TAB(30); " PROBLEM # 14"
40   LPRINT TAB(30); " -----------"
50   PRINT : PRINT " ENTER THE OPERATING FREQ. fo IN GHz"
60   INPUT fo: PRINT : PRINT " 1. fo=";fo;"GHz"
70   PRINT : PRINT " ENTER THE # OF THE STAGGER PERIODS n"
80   INPUT n : PRINT : PRINT " 2. n=";n
90   PRINT : PRINT " ENTER THE STAGGER PERIODS n1,n2,n3,n4"
100  INPUT n1,n2,n3,n4 : PRINT : PRINT " 3. T1 : T2 : T3 : T4 =";n1":"n2":"n3":"n4
110  PRINT : PRINT " ENTER THE TIME AVERAGE Tavg IN sec."
120  INPUT Tavg : PRINT : PRINT " 4. Tavg=";Tavg;"sec."
130  PRINT : PRINT : PRINT " G I V E N"
140  PRINT " ---------"
150  LPRINT : LPRINT : LPRINT " G I V E N"
160  LPRINT " ---------"
170  LPRINT : LPRINT " 1. fo=";fo;"GHz" SPC(10); " : OPERATING FREQ."
180  LPRINT : LPRINT " 2. n=";n SPC(14); " : # OF STAGGER PERIODS"
190  LPRINT : LPRINT " 3. T1:T2:T3:T4=";n1":"n2":"n3":"n4; " : RATIO OF STAGGER PERIODS"
200  LPRINT :LPRINT " 4. Tavg=";Tavg;"sec."; " : TIME AVERAGE"
230  PRINT : PRINT " 1. fo=";fo;"GHz" SPC(10); " : OPERATING FREQ."
240  PRINT : PRINT " 2. n=";n SPC(10); " : # OF STAGGER PERIODS"
250  PRINT : PRINT " 3. T1:T2:T3:T4=";n1":"n2":"n2":"n3":"n4; " : RATIO OF STAGGER PERIODS"
260  PRINT : PRINT " 4. Tavg=";Tavg;"sec."; " : TIME AVERAGE"
270  PRINT : PRINT : PRINT " PART a:"
280  PRINT " -------"
290  LPRINT : LPRINT : LPRINT " PART a:"
300  LPRINT " -------"
310  LET SUM=n1+n2+n3+n4
320  LET T1=n*n1/SUM*Tavg : T2=n*n2/SUM*Tavg : T3=n*n3/SUM*Tavg :
330  LET T4=n*n4/SUM*Tavg
340  LET T1=CSNG(T1*10^6) : T2=CSNG(T2*10^6) : T3=CSNG(T3*10^6) : T4=CSNG(T4*10^6)
350  PRINT : PRINT " 1. T1=";T1;"microsec."," 2. T2=";T2;"microsec."
360  PRINT : PRINT " 3. T3=";T3;"microsec."," 4. T4=";T4;"microsec."
370  LPRINT : LPRINT " 1. T1=";T1;"microsec."," 2. T2=";T2;"microsec."
```

```
380  LPRINT : LPRINT " 3. T3=";T3;"microsec."," 4.T4=";T4;"microsec."
390  PRINT : PRINT : PRINT " PART b:"
400  PRINT " -------"
410  LPRINT : LPRINT : LPRINT " PART b:"
420  LPRINT " -------"
430  LET C=3*10^8 : fo=fo*10^9 : l=C/fo
440  LET U1b1=l*(1/Tavg)*(1/1.02)*(SUM/n)
450  PRINT : PRINT " U1b1=";CINT(U1b1);"Knots"; " : FIRST BLIND SPEED"
460  LPRINT : LPRINT " U1b1=";CINT(U1b1);"Knots"; " : FIRST BLIND SPEED"
470  PRINT : PRINT " DO YOU WANT TO TRY AGAIN WORKER Y/N?"
480  INPUT A$
490  IF LEFT$(A$,1)="Y" OR LEFT$(A$,1)="y"  THEN 50
500  END
```

PROBLEM # 14

GIVEN

1. fo= 1 GHz : OPERATING FREQ.

2. n= 4 : # OF STAGGER PERIODS

3. T1:T2:T3:T4= 25 : 30 : 30 : 27 : 31 : RATIO OF STAGGER PERIODS

4. Tavg= .001 sec. : TIME AVERAGE

PART a:

1. T1= 884.956 microsec. 2. T2= 1061.95 microsec.

3. T3= 955.752 microsec. 4. T4= 1097.35 microsec.

PART b:

U1bl= 8309 Knots

```
10    PRINT : PRINT TAB(30); " PROBLEM #15"
20    PRINT TAB(30); " -----------"
30    LPRINT : LPRINT TAB(30); " PROBLEM #15"
40    LPRINT TAB(30); " -----------"
50    DIM N(50),A(50),B(50),W(50)
60    PRINT : PRINT " ENTER THE OPERATING FREQ. fo IN GHz"
70    INPUT fo : PRINT : PRINT " 1. fo=";fo;"GHz"
80    PRINT : PRINT " ENTER THE P.R.F fp IN KHz"
90    INPUT fp : PRINT : PRINT " 2. fp=";fp;"KHz"
100   PRINT : PRINT " ENTER NUMBER OF PULSE CANCELLER n, (maximum you can enter for this
 program is n=49)"
110   INPUT n : PRINT : PRINT " 3. n=";n
120   PRINT : PRINT " ENTER FREQ. f IN Hz, WHERE THE CLUTTER REJECTION WILL BE
 CALCULATED"
130   INPUT f : PRINT : PRINT " 4. f=";f;"Hz"
140   PRINT : PRINT " ENTER THE RADIAL VELOCITY OF THE TARGET Ur IN Knots"
150   INPUT Ur : PRINT : PRINT " 5. Ur=";Ur;"Knots"
160   '*****************************
170   '     PRINTS THE INPUT DATA
180   '*****************************
190   LPRINT : LPRINT : LPRINT " G I V E N"
200   LPRINT " ---------"
210   LPRINT : LPRINT " 1. fo=";fo;"GHz" SPC(10); " : OPERATING FREQ."
220   LPRINT : LPRINT " 2. fp=";fp;"KHz" SPC(10); " : P.R.F"
230   LPRINT : LPRINT " 3. n=";n SPC(14); " : NUMBER OF PULSE CANCELLER"
240   LPRINT : LPRINT " 4. f=";f;"Hz" SPC(11); " : FREQ. WHERE THE CLUTTER REJECTION WILL BE
 CALCULATED"
250   LPRINT : LPRINT " 5. Ur=";Ur;"Knots" SPC(6); " : RADIAL VELOCITY OF THE TARGET"
260   '******************************************
270   '     CALCULATIONS FOR PARTS a,b,c,d
280   '******************************************
290   LET fo=fo*10^9 : fp=fp*10^3 : C=3*10^8
300   LET l=C/fo : U1b1=CSNG(l*fp/1.02)
310   PRINT : PRINT : PRINT " PART a:"
320   PRINT " -------"
```

```
330  LPRINT : LPRINT : LPRINT " PART a:"
340  LPRINT " -------"
350  PRINT : PRINT " U1bl=";U1bl;"Knots"; " : FIRST BLIND SPEED"
360  LPRINT : LPRINT " U1bl=";U1bl;"Knots"; " : FIRST BLIND SPEED"
370  PRINT : PRINT : PRINT " PART b:"
380  PRINT " -------"
390  LPRINT : LPRINT : LPRINT " PART b:"
400  LPRINT " -------"
410  FOR I=1 TO n-1
420     N(0)=1 : N(I)=I
430     N(I)=N(I-1)*I
440  NEXT I
450  FOR J=1 TO n
460      B(J)=J-1
470      B(1)=1
480      B(0)=1
490     A(0)=1
500     A(J)=B(J)*A(J-1) ': PRINT A(J)
510   W(J)=(-1)^(J-1)*N(n-1)/(N(n-J)*A(J))
520  NEXT J
530  PRINT : PRINT " 1. T1 = T2 = T3 =";1/fp;"sec."; " : DELAYS OF THE 4 PULSE CANCELER"
540  LPRINT : LPRINT " 1. T1 = T2 = T3 =";1/fp;"sec."; " : DELAYS OF THE 4 PULSE CANCELER"
550  PRINT : PRINT " 2. THE WEIGHTS OF THE 4 PULSE CANCELER ARE : " : PRINT
560  LPRINT : LPRINT " 2. THE WEIGHTS OF THE 4 PULSE CANCELER ARE : " : LPRINT
570  FOR I=1 TO n
580    PRINT " W(";I;")";"=";W(I)".";  : LPRINT " W(";I;")";"=";W(I)".";
590  NEXT I
600  PRINT : PRINT : PRINT " PART c:"
610  PRINT " -------"
620  LPRINT : LPRINT : LPRINT " PART c:"
630  LPRINT " -------"
640  LET PI=3.14159 : REJ.=CSNG(-60*.4342945#*LOG(SIN(PI*f/fp)))
650  PRINT : PRINT " REJ.=";REJ.;"db"; " : CLUTTER REJECTION AT f=";f;"Hz"
660  LPRINT : LPRINT " REJ.=";REJ.;"db"; " : CLUTTER REJECTION AT f=";f;"Hz"
670  PRINT : PRINT : PRINT " PART d:"
```

```
680   PRINT " -------"
690   LPRINT : LPRINT : LPRINT " PART d:"
700   LPRINT " -------"
710   LET fd=CSNG(1.03*Ur/1)
720   PRINT : PRINT " fd=";fd;"Hz"; " : DOPPLER FREQ. WHERE THE BIPOLAR VIDEO WILL
 FLUCTUATE"
730   LPRINT : LPRINT " fd=";fd;"Hz"; " : DOPPLER FREQ. WHERE THE BIPOLAR VIDEO WILL
 FLUCTUATE"
740   PRINT : PRINT " DO YOU WANT TO TRY AGAIN FOR DIFFERENT OR THE SAME DATA Y/N?"
750   INPUT A$
760   IF LEFT$(A$,1)="Y" OR LEFT$(A$,1)="y" THEN 60
770   END
```

PROBLEM # 15

GIVEN

1. fo= 1 GHz : OPERATING FREQ.
2. fp= 1 KHz : P.R.F
3. n= 4 : NUMBER OF PULSE CANCELLER
4. f= 25 Hz : FREQ. WHERE THE CLUTTER REJECTION WILL BE CALCULATED
5. Ur= 200 Knots : RADIAL VELOCITY OF THE TARGET

PART a:

U1bl= 294.118 Knots : FIRST BLIND SPEED

PART b:

1. T1 = T2 = T3 = .001 sec. : DELAYS OF THE 4 PULSE CANCELER
2. THE WEIGHTS OF THE 4 PULSE CANCELER ARE :

W(1)= 1 . W(2)=-3 . W(3)= 3 . W(4)=-1 .

PART c:

REJ.= 66.3214db : CLUTTER REJECTION AT f= 25 Hz

PART d:

fd= 686.667 Hz : DOPPLER FREQ. WHERE THE BIPOLAR VIDEO WILL FLUCTUATE

APPENDIX B

A listing of the Electronic Warfare computer programs is provided as well as an output of the results for each one of these programs.

```
10   PRINT : PRINT TAB(30); " PROBLEM #1 "
11   PRINT TAB(30); "----------"
20   GOSUB 100 : GOSUB 850 : GOSUB 1060 : GOSUB 1510
30   GOSUB 1620   : GOSUB 1750   : GOSUB 1890 : GOSUB 2070 : GOSUB 2260
40   PRINT : PRINT " DO YOU WANT TO TRY AGAIN FOR DIFFERENT OR THE SAME DATA Y/N?"
50    INPUT D$
60   IF LEFT$(D$,1)="Y" OR LEFT$(D$,1)="y" THEN 20
70    END
80  '*********************************
90  '          INPUTS TH    ATA
100 '*********************************
110  PRINT : PRINT " ENTER THE OPERATING FREQ. f0 IN MHZ"
120  INPUT f0 : PRINT : PRINT " 1. f0=";f0;"MHZ"
130  PRINT : PRINT " ENTER THE PULSE WIDTH (long) T1 IN MICSEC."
140  INPUT T1 : PRINT : PRINT " 2. T1=";T1;"MICSEC"
150  PRINT : PRINT " ENTER THE PULSE WIDTH (short) Ts IN MICSEC."
160  INPUT Ts : PRINT : PRINT " 3. Ts=";Ts;"MICSEC."
170  PRINT : PRINT " ENTER THE PEAK OUTPUT POWER Pr IN KW"
180  INPUT Pr : PRINT : PRINT " 4. Pr=";Pr;"KW"
190  PRINT : PRINT " ENTER THE P.R.F fp IN HZ"
200  INPUT fp : PRINT : PRINT " 5. fp=";fp;"HZ"
210  PRINT : PRINT " ENTER THE BANDWIDTH (long pulse) Brl IN MHZ"
220  INPUT Brl : PRINT : PRINT " 6. Brl=";Brl;"MHZ"
230  PRINT : PRINT " ENTER THE BANDWIDTH (short pulse) Brs IN MHZ"
240  INPUT Brs : PRINT : PRINT " 7. Brs=";Brs;"MHZ"
250  PRINT : PRINT " ENTER THE ANTENNA SCAN FREQ. Wm IN R.P.M"
260  INPUT Wm : PRINT : PRINT " 8. Wm=";Wm;"R.P.M"
270  PRINT : PRINT " ENTER THE AZIMUTH BEAMWIDTH A.B IN Deg."
280  INPUT A.B : PRINT : PRINT " 9. A.B=";A.B;"Deg."
290  PRINT : PRINT " ENTER THE ELEVATION BEAMWIDTH E.B IN Deg."
300  INPUT E.B : PRINT : PRINT " 10. E.B=";E.B;"Deg."
310  PRINT : PRINT " ENTER THE ANTENNA NOISE TEMPERATURE Ta IN KELVIN"
320  INPUT Ta : PRINT : PRINT " 11. Ta=";Ta;"KELVIN"
330  PRINT : PRINT "ENTER THE FALSE ALARM PROBABILITY Pfa"
340  INPUT Pfa: PRINT : PRINT " 12. Pfa=";Pfa
```

```
350  PRINT : PRINT " IS THE INPUT DATA CORRECT Y/N?"
360  INPUT A$
370  IF LEFT$(A$,1)="Y" OR LEFT$(A$,1)="y" THEN 820
380  PRINT : PRINT " WHAT OF THE FOLLOWING DO YOU WANT TO CHANGE?"
390  PRINT : PRINT " 1. THE OPERATING FREQ.?"
400  PRINT : PRINT " 2. THE PULSE WIDTH (long) ?"
410  PRINT : PRINT " 3. THE PULSE WIDTH (short) ?"
420  PRINT : PRINT " 4. THE PEAK OUTPUT POWER"
430  PRINT : PRINT " 5. THE P.R.F"
440  PRINT : PRINT " 6. THE BANDWIDTH FOR THE LONG PULSE?"
450  PRINT : PRINT " 7. THE BANDWIDTH FOR THE SHORT PULSE?"
460  PRINT : PRINT " 8. THE ANTENNA SCAN FREQ.?"
470  PRINT : PRINT " 9. THE AZIMUTH BEAMWIDTH?"
480  PRINT : PRINT " 10. THE ELEVATION BEAMWIDTH?"
490  PRINT : PRINT " 11. THE ANTENNA NOISE TEMPERATURE?"
500  PRINT : PRINT " 12. THE FALSE ALARM PROBABILITY?"
510  INPUT C$
520  IF C$="1"  THEN PRINT : PRINT " ENTER THE OPERATING FREQ. f0 IN MHZ"
530  IF C$="1"  THEN INPUT f0 : PRINT : PRINT " 1. f0=";f0;"MHZ" : GOTO 760
540  IF C$="2"  THEN PRINT : PRINT " ENTER THE PULSE WIDTH (long) T1 IN MICSEC."
550  IF C$="2"  THEN INPUT T1 : PRINT : PRINT " 2. T1=";T1;"MICSEC." : GOTO 760
560  IF C$="3"  THEN PRINT : PRINT " ENTER THE PULSE WIDTH (short) Ts IN MICSEC."
570  IF C$="3"  THEN INPUT Ts : PRINT : PRINT " 3. Ts=";Ts;"MICSEC." : GOTO 760
580  IF C$="4"  THEN PRINT : PRINT " ENTER THE PEAK POWER OUTPUT Pr IN KW"
590  IF C$="4"  THEN INPUT Pr : PRINT : PRINT " 4. Pr=";Pr;"KW" : GOTO 760
600  IF C$="5"  THEN PRINT : PRINT " ENTER THE P.R.F pf IN HZ"
610  IF C$="5"  THEN INPUT pf : PRINT : PRINT " 5. pf=";pf;"HZ" : GOTO 760
620  IF C$="6"  THEN PRINT : PRINT " ENTER THE BANDWIDTH (long pulse) Brl IN MHZ"
630  IF C$="6"  THEN INPUT Brl : PRINT : PRINT " 6. Brl=";Brl;"MHZ" : GOTO 760
640  IF C$="7"  THEN PRINT : PRINT " ENTER THE BANDWIDTH (short pulse) Brs IN MHZ"
650  IF C$="7"  THEN INPUT Brs : PRINT : PRINT " 7. Brs=";Brs;"MHZ" : GOTO 760
660  IF C$="8"  THEN PRINT : PRINT " ENTER THE ANTENNA SCAN FREQ. Wm IN R.P.M"
670  IF C$="8"  THEN INPUT Wm : PRINT : PRINT " 8. Wm=";Wm;"R.P.M" : GOTO 760
680  IF C$="9"  THEN PRINT : PRINT " ENTER THE AZIMUTH BEAMWIDTH A.B IN Deg."
690  IF C$="9"  THEN INPUT A.B : PRINT : PRINT " 9. A.B=";A.B;"Deg." : GOTO 760
```

```
700  IF C$="10" THEN PRINT : PRINT " ENTER THE ELEVATION BEAMWIDTH E.B IN Deg."
710  IF C$="10"  THEN INPUT E.B : PRINT : PRINT " 10. E.B=";E.B;"Deg." : GOTO 760
720  IF C$="11"  THEN PRINT : PRINT " ENTER THE ANTENNA NOISE TEMPERATURE Ta IN KELVIN"
730  IF C$="11"  THEN INPUT Ta : PRINT : PRINT " 11. Ta=";Ta;"KELVIN" : GOTO 760
740  IF C$="12" THEN PRINT : PRINT " ENTER THE FALSE ALARM PROBABILITY Pfa"
750  IF C$="12"  THEN INPUT Pfa : PRINT : PRINT " 12. Pfa= ";Pfa; : GOTO 760
760  PRINT : PRINT " IS EVERYTHING O.K NOW?"
770  INPUT B$
780  IF LEFT$(B$,1)="Y" OR LEFT$(B$,1)="y" THEN 820
790  PRINT : PRINT " WHAT DO YOU WANT TO CHANGE AGAIN?"
800  PRINT : PRINT " HIT ANY KEY IN YOUR KEYBOARD AND EVERYTHING WILL WORK FOR YOU
 MALAKA"
810  INPUT F$  : GOTO 390
820  RETURN
830 '*********************************
840 '     PRINTS THE INPUT DATA
850 '*********************************
860  LPRINT : LPRINT TAB(30); " PROBLEM #1"
870  LPRINT TAB(30); " ----------"
880  LPRINT : LPRINT " G I V E N"
890  LPRINT " ---------"
900  PRINT : PRINT " G I V E N"
920  LPRINT : LPRINT " 1. f0=";f0;"MHZ" TAB(20);" : OPERATING FREQ."
930  LPRINT : LPRINT " 2. Tl=";Tl;"MICSEC." TAB(20);" : PULSE WIDTH (long)"
940  LPRINT : LPRINT " 3. Ts=";Ts;"MICSEC." TAB(20);" : PULSE WIDTH (short)"
950  LPRINT : LPRINT " 4. Pr=";Pr;"KW" TAB(20);" : PEAK OUTPUT POWER"
960  LPRINT : LPRINT " 5. fp=";fp;"HZ" TAB(20);" : P.R.F"
970  LPRINT : LPRINT " 6. Brl=";Brl;"MHZ" TAB(20);" : BANDWIDTH (long pulse)"
980  LPRINT : LPRINT " 7. Brs=";Brs;"MHZ" TAB(20);" : BANDWIDTH (short pulse)"
990  LPRINT : LPRINT " 8. Wm=";Wm;"R.P.M" TAB(20);" : ANTENNA SCAN FREQ."
1000 LPRINT : LPRINT " 9. A.B=";A.B;"Deg." TAB(20);" : AZIMUTH BEAMWIDTH"
1010 LPRINT : LPRINT " 10. E.B=";E.B;"Deg." TAB(20);" : ELEVATION BEAMWIDTH"
1020 LPRINT : LPRINT " 11. Ta=";Ta;"KELVIN" TAB(20);" : ANTENNA NOISE TEMPERATURE"
1030 LPRINT : LPRINT " 12. Pfa=";Pfa; TAB(20);" : FALSE ALARM PROBABILITY"
1040 RETURN
```

```
1050*********************************************
1060 '        CALCULATION & PRINTOUT FOR PART a
1070*********************************************
1080 PRINT : PRINT : PRINT " PART a:"
1090 PRINT "-------"
1100 LPRINT : LPRINT : LPRINT " PART a:"
1110 LPRINT "-------"
1120 PRINT : PRINT " ENTER RADAR'S CROSS SECTION OF TARGET Sav IN sq.m"
1130 INPUT S
1140 PRINT : PRINT " ENTER THE PROBABILITY OF DETECTION Pd"
1150 INPUT Pd
1160 PRINT : PRINT " ENTER THE RECEIVER'S NOISE FIGURE F1 IN db"
1170 INPUT F1
1180 LET n=CINT(A.B*fp*60/(360*Wm))
1190 PRINT : PRINT " FROM Fig. 2.8(a) (SKOLNIK Pg.31) YOU CANFIND THE INTEGRATION IMR.
        FACTOR Ii(n) IN db"
1200 PRINT : PRINT " SINCE YOU KNOW :"
1210 PRINT : PRINT " (a). n=A.B*fp*60/(360*Wm)=";n; " : #OF HITS INTEGRATED"
1220 PRINT : PRINT " (b). Pd=";Pd; " : PROBABILITY OF DETECTION"
1230 PRINT : PRINT " ENTER THE INTEGRATION IMR. FACTOR Ii(n) (numeric value)"
1240 INPUT Ii
1250 PRINT : PRINT " FROM Fig. 2.7 (SKOLNIK Pg. 28) YOU CAN FIND THE (S/N)1 IN db"
1260 PRINT : PRINT " ENTER THE (S/N)1 IN db"
1270 INPUT A
1280 LET T0=290               'KELVIN
1290 LET K=1.38*10^-23          'BOLTZMAN'S CONSTANT
1300 LET PI=3.14159
1310 LET C=3*10^8              'm/s
1320 LET f0=f0*10^6            'convertion from MHz to Hz
1330 LET Brl=Brl*10^6          'convertion from MHz to Hz
1340 LET Pr=Pr*10^3            'convertion from MW to W
1350 LET l=C/f0               'm/s
1360 LET G=41250!/(A.B*E.B)          'ANTENNA GAIN
1370 LET Ae=l^2*G/(4*PI)        'antenna effective aperture
1380 LET F2=F1/10 : F3=10^F2
```

```
1390 LET Te=(F3-1)*T0
1400 LET B=K*T0*(Ta+Te)*Br1/290
1410 LET A1=A/10:A2=10^A1
1420 LET R=CSNG(SQR(SQR(Pr*G*Ae*S*I1/((4*PI)^2*B*A2)))) 'long pulse
1430 LET R1=CSNG(R*(1/5)^(1/4))       'short pulse
1450 PRINT:PRINT " 1(a).
     R=Pr*G*Ae*Sav*n*Ei(n)/((4*PI)^2*K*(Ta+Te)*Br1*(S/N)max.)^(1/4)=";R/1000;"KM";"
     MAX.DETECTION RANGE FOR THE LONG PULSE"
1460 PRINT:PRINT " 2(a). R1=R*(1/5)^(1/4)=";R1/1000;"KM";" :MAX RANGE FOR THE SHORT
     PULSE"
1470 LPRINT:LPRINT " 1(a).
     R=Pr*G*Ae*Sav*n*Ei(n)/((4*PI)^2*K(Ta+Te)*Br1*(S/N)max.)^(1/4)=";R/1000;"KM";"
     MAX.DETECTION RANGE FOR THE LONG PULSE"
1480 LPRINT:LPRINT " 2(a). R1=R*(1/5)^(1/4)=";R1/1000;"KM"; " : MAX RANGE FOR THE SHORT
     PULSE"
1490 RETURN
1500'************************************
1510 ' CALCULATION& PRINTOUT FOR PART b:
1520'************************************
1530 PRINT:PRINT:PRINT " PART b:"
1540 PRINT " -------"
1550 LPRINT:LPRINT:LPRINT " PART b:"
1560 LPRINT " -------"
1570 LET Ru=CSNG(C/(2*fp))
1580 PRINT:PRINT " 1(b). Ru=";Ru/1000;"KM" " : MAX. UNAMBIGUOUS RANGE"
1590 LPRINT:LPRINT " 1(b). Ru=";Ru/1000;"KM" " : MAX. UNAMBIGUOUS RANGE"
1600 RETURN
1610'************************************
1620 ' CALCULATION& PRINTOUT FOR PART c:
1630'************************************
1640 PRINT:PRINT:PRINT " PART c:"
1650 PRINT " -------"
1660 LPRINT:LPRINT:LPRINT " PART c:"
1670 LPRINT " -------"
1680 PRINT:PRINT "ENTER THE RADAR CROSS SECTION IN dbsm"
```

```
1690 INPUT Slev
1700 LET R2=CSNG(R/1000*10^(1/4))
1710 PRINT :PRINT " 1(c). R2=10^(1/4)*R=";R2;"KM"; "RANGE AT WHICH THE AIRCRAFT WILL BE
        DETECTED FOR R.C.S=10sq.m & FOR THE LONG PULSE"
1720 LPRINT :LPRINT " 1(c). R2=10^(1/4)*R=";R2;"KM"; " RANGE AT WHICH THE AIRCRAFT WILL BE
        DETECTED FOR R.C.S=10sq.m & FOR THE LONG PULSE"
1730 RETURN
1740'************************************
1750 ' CALCULATION& PRINTOUT FOR PART d:
1760'************************************
1770 PRINT : PRINT : PRINT " PART d:"
1780 PRINT "--------"
1790 LPRINT : LPRINT : LPRINT " PART d:"
1800 LPRINT "--------"
1810 PRINT : PRINT " ENTER THE RADAR ANTENNA HEIGHT ABOVE THE SEA h1 IN ft"
1820 INPUT h1
1830 LET h2=(R2/1.61-SQR(2*h1))^2
1840 LET h2=CSNG(h2/2)
1850 PRINT : PRINT " 1(d). h2=R2(m1)-SQR(2*h1(ft)))/2=";h2;" ft";" : MIN. ALTITUDE AT WHICH
        THE RADAR CAN SEE THE TARGET"
1860 LPRINT :LPRINT " 1(d). (h2=R2(m1)-SQR(2*h1(ft)))/2=";h2;" ft";" : MIN. ALTITUDE AT WHICH
        THE RADAR CAN SEE THE TARGET"
1870 RETURN
1880'************************************
1890 ' CALCULATION& PRINTOUT FOR PART e:
1900'************************************
1910 PRINT : PRINT : PRINT " PART e:"
1920 PRINT "--------"
1930 LPRINT : LPRINT : LPRINT " PART e:"
1940 LPRINT "--------"
1950 PRINT : PRINT " ENTER THE CIRCULARY POLARIZED ANTENNA'S GAIN G0 IN db"
1960 INPUT G0
1970 LET G1=G0/10 : G2=10^G1
1980 PRINT : PRINT " ENTER THE TOTAL SYSTEM LOSSES Ls IN db"
1990 INPUT Ls
```

```
2000 LET Ls1=Ls/10:Ls2=10^Ls1
2010P=Pr*G*1^2*G2/((4*PI)^2*(R2*1000)^2*Ls2)
2020 LET P=CSNG(10*.4342945#*LOG(P)+30)
2030 PRINT:PRINT " 1(e).P=Pr*G*1^2*G2/((4*PI)^2*R2^2*Ls)=";P;"dbm";" :SINGLE PULSE POWER
       AT THE ANTENNA TERMINALS OUTPUT"
2040 LPRINT:LPRINT " 1(e).P=Pr*G*1^2*G2/((4*PI)^2*R2^2*Ls)=";P;"dbm";" :SINGLE PULSE
       POWER AT THE ANTENNA TERMINALS OUTPUT"
2050 RETURN
2060'************************************
2070 ' CALCULATION& PRINTOUT FOR PART f:
2080'************************************
2090 PRINT:PRINT:PRINT " PART f:"
2100 PRINT "-------"
2110 LPRINT:LPRINT:LPRINT " PART f:"
2120 LPRINT "--------"
2130 LET K1=1640
2140 LET K2=400
2150 LET T1=T1*10^-6
2160 LET Cf=4/(1+(1/(T1*Br1))^2)*(fp/K1)^(1/3)
2170 LET Cf1=4/(1+(1/(T1*Br1))^2)*(fp/K2)^(1/3)
2180 LET Cf=CSNG(10*.4342945#*LOG(Cf))
2190 LET Cf1=CSNG(10*.4342945#*LOG(Cf1))
2200 PRINT:PRINT " 1(f).Cf=4/(1+(1/(T1*Br1))^2)*(fp*K)^(1/3)=";Cf;"db"; " :CAMOUFLAGE
       FACTOR FOR K=";K1
2210 PRINT:PRINT " 2(f).Cf1=4/(1+(1/(T1*Br1))^2)*(fp*K)^(1/3)=";Cf1;"db";" :CAMOUFLAGE
       FACTOR FOR K=";K2
2220 LPRINT:LPRINT " 1(f).Cf=4/(1+(1/(T1*Br1))^2)*(fp*K)^(1/3)=";Cf;"db"; " :CAMOUFLAGE
       FACTOR FOR K=";K1
2230 LPRINT:LPRINT " 2(f).Cf1=4/(1+(1/(T1*Br1))^2)*(fp*K)^(1/3)=";Cf1;"db";" :CAMOUFLAGE
       FACTOR FOR K=";K2
2240 RETURN
2250'************************************
2260 ' CALCULATION& PRINTOUT FOR PART g:
2270'************************************
2280 PRINT:PRINT:PRINT " PART g:"
```

```
2290 PRINT "-------"
2300 LPRINT : LPRINT : LPRINT " PART g:"
2310 LPRINT "-------"
2320 PRINT : PRINT " ENTER THE VALUE OF THE S/J IN db"
2330 INPUT C1 : C2=C1/10 : C3=10^C2
2340 PRINT : PRINT " ENTER THE BURNTHROUGH RANGE Rb IN n.miles"
2350 INPUT Rb
2360 LET Rb=Rb*1.85*10^3
2370 PRINT : PRINT " ENTER THE THE FREQ. Br IN MHz THE JAMMER TRANSMITS"
2380 INPUT Br : Br=Br*10^6
2390 PRINT : PRINT " ENTER THE GAIN OF THE JAMMING ANTENNA Gj IN db"
2400 INPUT Gj : Cj1=Cj/10 : Cj2=10^Cj1
2410 Pj=CSNG(Pr*G*S1av*Ls2*C3/(4*PI*Rb^2*Br1*Cj2))
2420 Pj1=CSNG(Pr*G*S1av*Ls2*C3/(4*PI*Rb^2*Br*Cj2))
2430 PRINT : PRINT " 1(g).Pj=Pr*G*Sav*Ls*(S/J)/(4*PI*Rb^2*Br1*Cj)=";Pj*10^6;"W/MHz";":
      JAMMER OUTPUT POWER FOR LONG PULSE"
2440 PRINT : PRINT " 2(g).Pj=Pr*G*Sav*Ls*(S/J)/(4*PI*Rb^2*Br*Cj)=";Pj1*10^6;"W/MHz";":
      JAMMER OUTPUT POWER FOR Br="Br/10^6;"MHz
2450 LPRINT : LPRINT " 1(g).Pj=Pr*G*Sav*Ls*(S/J)/(4*PI*Rb^2*Br1*Cj)=";Pj*10^6;"W/MHz";":
      JAMMER OUTPUT POWER FOR LONG PULSE"
2460 LPRINT : LPRINT " 2(g).Pj=Pr*G*Sav*Ls*(S/J)/(4*PI*Rb^2*Br*Cj)=";Pj1*10^6;"W/MHz";":
      JAMMER OUTPUT POWER FOR Br="Br/10^6;"MHz
2470 RETURN
```

PROBLEM# 1

GIVEN

1. f0= 5600 MHZ : OPERATING FREQ.
2. Tl= 1.3 MICSEC. : PULSE WIDTH (long)
3. Ts= .25 MICSEC. : PULSE WIDTH (short)
4. Pr= 200 KW : PEAK OUTPUT POWER
5. fp= 650 HZ : P.R.F
6. Brl= 1 MHZ : BANDWIDTH (long pulse)
7. Brs= 5 MHZ : BANDWIDTH (short pulse)
8. Wm= 16 R.P.M : ANTENNA SCAN FREQ.
9. A.B= 1.5 Deg. : AZIMUTH BEAMWIDTH
10. E.B= 14 Deg. : ELEVATION BEAMWIDTH
11. Ta= 75 KELVIN : ANTENNA NOISE TEMPERATURE
12. Pfa= 1E-11 : FALSE ALARM PROBABILITY

PART a:

1(a).R=Pr*G*Ae*Sav*n*Ei(n)/((4*PI)^2*K*(Ta+Te)*Brl*(S/N)max.)^(1/4)=47.972KM:MAX DETECTION RANGE FOR THE LONG PULSE

2(a). R1=R*(1/5)^(1/4)=32.0808 KM: MAX RANGE FOR THE SHORT PULSE

PART b:

1(b). Ru= 230.769 KM : MAX. UNAMBIGUOUS RANGE

PART c:

1(c). R2=10^(1/4)*R=85.3076 KM RANGE AT WHICH THE AIRCRAFT WILL BE DETECTED FOR R.C.S=10sq.m & FOR THE LONG PULSE

PART d:

1(d). h2=R2(mi)-SQR(2*h1(ft)))/2=923.902 ft :MIN. ALTITUDE AT WHICH THE RADAR CAN SEE THE TARGET

PART e:

1(e).P=Pr*G*1^2*G2/((4*PI)^2*R2^2*Ls)=-33.0829 dbm :SINGLE PULSE POWER AT THE ANTENNA TERMINALS OUTPUT

PART f:

1(f). Cf=4/(1+(1/(T1*Br1))^2)*(fp*K)^(1/3)=2.66218 db : CAMOUFLAGE FACTOR FOR K= 1640

2(f). Cf1=4/(1+(1/(T1*Br1))^2)*(fp*K)^(1/3)=4.70479 db : CAMOUFLAGE FACTOR FOR K= 400

PART g:

1(g). Pj=Pr*G*Sav*Ls*(S/J)/(4*PI*Rb^2*Br1*Cj)=5.76344 W/MHz :JAMMER OUTPUT POWER FOR LONG PULSE

2(g). Pj=Pr*G*Sav*Ls*(S/J)/(4*PI*Rb^2*Br*Cj)=.192115 W/MHz :JAMMER OUTPUT POWER FOR Br= 30 MHz

```
10   PRINT : PRINT TAB(30) " PROBLEM #2 "
20   PRINT TAB(30); " -----------"
30   GOSUB 100 : GOSUB 530  : GOSUB 690
40   GOSUB 840 : GOSUB 950 : GOSUB 1060
50   PRINT : PRINT " DO YOU WANT TO TRY AGAIN FOR DIFFERENT OR THE SAME DATA Y/N?"
60    INPUT D$
70   IF LEFT$(D$,1)="Y"  OR LEFT$(D$,1)="y"  THEN 30
80    END
90   '*********************************
100  '          INPUTS THE DATA
110  '*********************************
120  PRINT : PRINT " ENTER THE OPERATING FREQ. f0  IN MHz "
130  INPUT f0 : PRINT : PRINT " 1. f0=";f0;"MHz "
140  PRINT : PRINT " ENTER THE DIMENSIONS OF THE RECTANGULAR TRANSMIT ANTENNA d1,d2
 IN METERS"
150  INPUT d1,d2 : PRINT : PRINT " 2. d1xd2="d1 "x" d2 " m"
160  PRINT : PRINT " ENTER THE #OF ELEMENTS OF THE RECT. ARRAY,TRANSMIT ANTENNA N "
170  INPUT N1 : PRINT : PRINT " 3. N=";N1
180  PRINT : PRINT " ENTER THE ILLUMINATION EFFICIENCY OF THE ARRAY Rr"
190  INPUT Rr : PRINT : PRINT " 4. Rr=";Rr
200  PRINT : PRINT " ENTER THE TOTAL LOSSES Ls (feed & phase shifter) IN db"
210  INPUT Ls : PRINT : PRINT " 5. Ls=";Ls;"db"
220  PRINT : PRINT " IS THE INPUT DATA CORRECT Y/N?"
230  INPUT A$
240  IF LEFT$(A$,1)="Y"  OR LEFT$(A$,1)="y"  THEN 500
250  IF A$="y"   THEN 1041
260  IF A$="N"   THEN PRINT " WHAT OF THE FOLLOWING DO YOU WANT TO CHANGE?"
270  IF A$="n"   THEN PRINT " WHAT OF THE FOLLOWING DO YOU WANT TO CHANGE?"
280  PRINT : PRINT " 1. THE OPERATING FREQ.?"
290  PRINT : PRINT " 2. THE DIMENSIONS OF THE RECT.ARRAY?"
300  PRINT : PRINT " 3. #OF THE ELEMENTS?"
310  PRINT : PRINT " 4. ILLUMINATION EFFICIENCY?"
320  PRINT : PRINT " 5. THE TOTAL LOSSES?"
330  INPUT C$
340  IF C$="1"   THEN PRINT : PRINT " ENTER THE OPERATING FREQ. f0 IN MHz"
```

```
350  IF C$="1"  THEN INPUT f0 : PRINT : PRINT " 1. f0=";f0;"MHz" : GOTO 440
360  IF C$="2"  THEN PRINT : PRINT " ENTER THE DIMENSIONS OF THE RECT. TRANSMIT
     ANTENNA d1,d2 INMETERS"
370  IF C$="2"  THEN INPUT d1,d2 : PRINT : PRINT " 2. d1xd2="d1 "x" d2 " m"  : GOTO 440
380  IF C$="3"  THEN PRINT : PRINT " ENTER THE #OF ELEMENTS OF THE RECT.
     ARRAY,TRANSMIT ANTENNAN "
390  IF C$="3"  THEN INPUT N1 : PRINT : PRINT " 3. N=";N1  : GOTO 440
400  IF C$="4"  THEN PRINT : PRINT " ENTER THE ILLUMINATION EFFICIENCY OF THE ARRAY Rr"
410  IF C$="4"  THEN INPUT Rr : PRINT : PRINT " 4. Rr=";Rr  : GOTO 440
420  IF C$="5"  THEN PRINT : PRINT " ENTER THE TOTAL LOSSES Ls (feed & phase shifter) IN
     db"
430  IF C$="5"  THEN INPUT Ls : PRINT : PRINT " 5. Ls=";Ls;"db" : GOTO 440
440  PRINT : PRINT " IS EVERYTHING O.K NOW?"
450  INPUT B$
460  IF LEFT$(B$,1)="Y"  OR LEFT$(B$,1)="y"  THEN 500
470  PRINT : PRINT " WHAT DO YOU WANT TO CHANGE AGAIN?"
480  PRINT : PRINT " HIT ANY KEY IN YOUR KEYBOARD AND EVERYTHING WILL WORK FOR YOU
     MALAKA"
490  INPUT F$   : GOTO 280
500  RETURN
510 '**********************************
520  '      PRINTS THE INPUT DATA
530 '**********************************
540  LPRINT : LPRINT TAB(30); " PROBLEM #2"
550  LPRINT  TAB(30); " ----------"
560  LPRINT : LPRINT " G I V E N"
570  LPRINT " ---------"
580  LPRINT : LPRINT " 1. f0=";f0;"MHz" TAB(20) " : OPERATING FREQ."
590  LPRINT : LPRINT " 2. d1xd2="d1 "x" d2 " m" TAB(20); " : DIMENSIONS OF THE ARRAY
     ANTENNA"
600  LPRINT : LPRINT " 3. N=";N1 TAB(20); " : #OF ELEMENTS OF THE ARRAY ANTENNA"
610  LPRINT : LPRINT " 4. Rr=";Rr TAB(20); " : ILLUMINATION EFF. OF THE ARRAY"
620  LPRINT : LPRINT " 5. Ls=";Ls;"db" TAB(20); " : TOTAL LOSSES (feed & phase shifter)"
670  RETURN
680 '*****************************************
```

```
690  ' CALCULATION & PRINTOUT FOR PART a:
700 '****************************************
710  PRINT : PRINT : PRINT " PART a:"
720  PRINT " -------"
730  LPRINT : LPRINT : LPRINT " PART a:"
740  LPRINT " -------"
750  LET Ls1=10^(-Ls/10) :  A=d1*d2
760  LET Ae= Rr*Ls1*A : PI=3.14159
770  LET C=3*10^8 : f0=f0*10^6
780  LET l=C/f0 : Gp=CSNG(4*PI*Ae/(l^2))
790 LET Gp1=CSNG(10*.4342945#*LOG(Gp))
800  PRINT : PRINT " 1(a). Gp=4*PI*Ae/(l^2)=";Gp;" numeric";" or";Gp1;"db"; " : POWER GAIN"
810  LPRINT : LPRINT " 1(a). Gp=4*PI*Ae/(l^2)=";Gp;" numeric";" or";Gp1;"db"; " : POWER GAIN"
820  RETURN
830 '****************************************
840  ' CALCULATION & PRINTOUT FOR PART b:
850 '****************************************
860  PRINT : PRINT : PRINT " PART b:"
870  PRINT " -------"
880  LPRINT : LPRINT : LPRINT " PART b:"
890  LPRINT " -------"
900 LET TH=CSNG(SQR(41250!/(Gp/Ls1)))
910 PRINT : PRINT " 1(b). TH=SQR(41250!/(Gp/Ls1))=";TH;"Deg."; " : BEAMWIDTH"
920 LPRINT : LPRINT " 1(b). TH=SQR(41250!/(Gp/Ls1))=";TH;"Deg."; " : BEAMWIDTH"
930  RETURN
940 '****************************************
950  ' CALCULATION & PRINTOUT FOR PART c:
960 '****************************************
970  PRINT : PRINT : PRINT " PART c:"
980  PRINT " -------"
990  LPRINT : LPRINT : LPRINT " PART c:"
1000 LPRINT " -------"
1010 LET d=CSNG(d1/SQR(N1))
1020 PRINT : PRINT " 1(c). d=d1/SQR(N1)=";d; " : SPACING BETWEEN ELEMENTS"
1030 LPRINT : LPRINT " 1(c). d=d1/SQR(N1)=";d; " : SPACING BETWEEN ELEMENTS"
```

```
1040 RETURN
1050'*************************************
1060 '  CALCULATION & PRINTOUT FOR PART d:
1070'*************************************
1080 PRINT : PRINT : PRINT " PART d:"
1090 PRINT "-------"
1100 LPRINT : LPRINT : LPRINT " PART d:"
1110 LPRINT "-------"
1120 LET Gdel=CSNG(12795/N1)
1130 LET Gdel1=CSNG(10*.4342945**LOG(Gdel))
1140 PRINT:PRINT " 1(d). Gdel=Gdarray/Gdgroup=";Gdel;"numeric";" or";Gdel1;"db";":
 DIRECTIVE GAIN OF AN ELEMENT"
1150 LPRINT : LPRINT " 1(d). Gdel=Gdarray/Gdgroup=";Gdel;"numeric";" or";Gdel1;"db";":
 DIRECTIVE GAIN OF AN ELEMENT"
1160 RETURN
```

PROBLEM#2

GIVEN

1. f0= 442 MHz : OPERATING FREQ.

2. d1xd2= 26.9 x 26.9 m : DIMENSIONS OF THE ARRAY ANTENNA

3. N= 5184 : #OF ELEMENTS OF THE ARRAY ANTENNA

4. Rr= .65 : ILLUMINATION EFF. OF THE ARRAY

5. Ls= 1.8 db : TOTAL LOSSES (feed & phase shifter)

PART a:

1(a). Gp=4*PI*Ae/(1^2)= 8476.75 numeric or 39.2823 db: POWER GAIN

PART b:

1(b).TH=SQR(41250l/(Gp/Ls1))= 1.79307 Deg.: BEAMWIDTH

PART c:

1(c). d=d1/SQR(N1)=.373611 : SPACING BETWEEN ELEMENTS

PART d:

1(d). Gdel=Gdarray/Gdgroup=2.46817 numeric or 3.92375 db : DIRECTIVE GAIN OF AN ELEMENT

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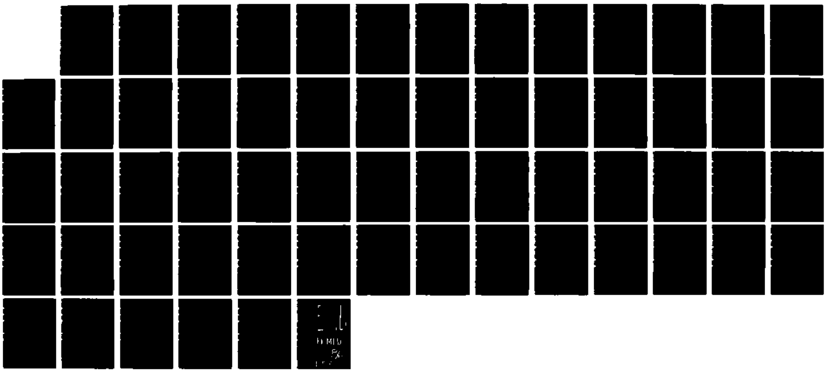

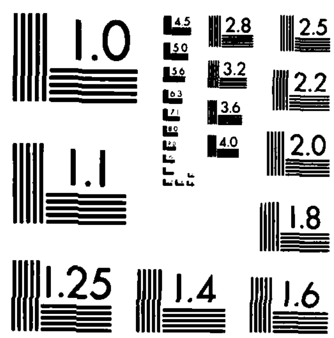

MICROCOPY RESOLUTION TEST CHART

ƆARDS-1963-A

```
10  PRINT : PRINT TAB(30) " PROBLEM #3 "
20  PRINT TAB(30); " --------"
30  GOSUB 100  : GOSUB 1170
40  GOSUB 1430 : GOSUB 1590
50  PRINT : PRINT " DO YOU WANT TO TRY AGAIN FOR DIFFERENT OR THE SAME DATA Y/N?"
60  INPUT D$
70  IF LEFT$(D$,1)="Y" OR LEFT$(D$,1)="y"   THEN 30
80  END
90  '**********************************
100 '          INPUTS THE DATA
120 '**********************************
130 PRINT : PRINT " ENTER THE OUTPUT PEAK POWER Pt IN W"
140 INPUT Pt : PRINT : PRINT " 1. Pt=";Pt;"W"
150 PRINT : PRINT " ENTER THE BORESIGHT ANTENNA GAIN Gt IN db"
160 INPUT Gt : PRINT : PRINT " 2. Gt=";Gt;"db"
170 PRINT : PRINT " ENTER THE OPERATING FREQ. f0 In GHz"
180 INPUT f0 : PRINT : PRINT " 3. f0=";f0;"GHz"
190 PRINT : PRINT " ENTER THE RF LOSSES Lp IN db"
200 INPUT Lp : PRINT : PRINT " 4. Lp=";Lp;"db"
210 PRINT : PRINT " ENTER THE RECEIVER NOISE BANDWIDTH Bn IN MHz"
220 INPUT Bn : PRINT : PRINT " 5. Bn=";Bn;"MHz"
230 PRINT : PRINT " ENTER THE RECEIVER NOISE FIGURE F IN db"
240 INPUT F : PRINT : PRINT " 6. F=";f;"db"
250 PRINT : PRINT " ENTER THE PULSE WIDTH T IN ns"
260 INPUT T : PRINT : PRINT " 7. T=";T;"ns"
270 PRINT : PRINT " ENTER THE P.R.F fp IN KHz"
280 INPUT fp : PRINT : PRINT " 8. fp=";fp;"KHz"
290 PRINT : PRINT " ENTER THE INTEGRATION TIME T1 IN msec."
300 INPUT T1 : PRINT : PRINT " 9. T1=";T1;"msec."
310 PRINT : PRINT " ENTER THE WEATHER ATTENUATION At IN db/KM"
320 INPUT At : PRINT : PRINT " 10. At=";At;"db/KM"
330 PRINT : PRINT " ENTER THE SKY TEMPERATURE Ta IN KELVIN"
340 INPUT Ta : PRINT : PRINT " 11. Ta=";Ta;"KELVIN"
350 PRINT : PRINT " ENTER THE TARGET RCS IN dbsm"
360 INPUT RCS : PRINT : PRINT " 12. RCS=";RCS;"dbsm"
```

```
370 PRINT : PRINT " ENTER THE DEG. OF THE PENCIL BEAM PB (part b)"
380 INPUT PB : PRINT : PRINT " 13. PB=";PB;"Deg."
390 PRINT : PRINT " ENTER THE (J/S) JS IN db (part b)"
400 INPUT JS : PRINT : PRINT " 14. (J/S)=";JS;"db"
410 PRINT : PRINT " ENTER THE RANGE R IN KM (part c)"
420 INPUT R : PRINT : PRINT " 15. R=";R;"KM"
430 PRINT : PRINT " ENTER THE RF LOSSES RFL IN db (part d)"
440 INPUT RFL : PRINT : PRINT " 16. RFL=";RFL;"db"
450 PRINT : PRINT " ENTER THE ILLUMINATION EFFICIENCY η (part d)"
460 INPUT η : PRINT : PRINT " 17. η=";η
470 PRINT : PRINT " ENTER THE CROSSOVER LOSSE Lco IN db"
480 INPUT Lco : PRINT : PRINT " 18. Lco=";Lco;"db"
490 PRINT : PRINT " IS THE INPUT DATA CORRECT Y/N?"
500 INPUT A$
510 IF LEFT$(A$,1)="Y" OR LEFT$(A$,1)="y" THEN 1150
520 PRINT " WHAT OF THE FOLLOWING DO YOU WANT TO CHANGE?"
530 PRINT : PRINT " 1. OUTPUT PEAK POWER?"
540 PRINT : PRINT " 2. THE BORESIGHT ANTENNA GAIN?"
550 PRINT : PRINT " 3. THE OPERATING FREQ.?"
560 PRINT : PRINT " 4. THE RF LOSSES?"
570 PRINT : PRINT " 5. THE RECEIVER'S NOISE BANDWIDTH?"
580 PRINT : PRINT " 6. THE RECEIVER'S NOISE FIGURE?"
590 PRINT : PRINT " 7. THE PULSE WIDTH?"
600 PRINT : PRINT " 8. THE P.R.F?"
610 PRINT : PRINT " 9. THE INTEGRATION TIME?"
620 PRINT : PRINT " 10. THE WEATHER ATTENUATION?"
630 PRINT : PRINT " 11. THE SKY TEMPERATURE?"
640 PRINT : PRINT " 12. THE TARGET'S RCS?"
650 PRINT : PRINT " 13. THE PENCIL BEAMWIDTH?"
660 PRINT : PRINT " 14. THE (J/S) RATIO?"
670 PRINT : PRINT " 15. THE RANGE?"
680 PRINT : PRINT " 16. THE RF LOSSES for part c?"
690 PRINT : PRINT " 17. THE ILLUMINATIONEFFICIENCY?"
700 PRINT : PRINT " 18. THE CROSSOVER LOSS?"
710 INPUT C$
```

```
720  IF C$="1"  THEN PRINT : PRINT " ENTER THE OUTPUT PEAK POWER Pt IN W"
730  IF C$="1"  THEN INPUT Pt : PRINT : PRINT " 1. Pt=";Pt;"W" : GOTO 1090
740  IF C$="2"  THEN PRINT : PRINT " ENTER THE BORESIGHT ANTENNA GAIN Gt IN db"
750  IF C$="2"  THEN INPUT Gt : PRINT : PRINT " 2. Gt=";Gt;"db" : GOTO 1090
760  IF C$="3"  THEN PRINT : PRINT " ENTER THE OPERATING FREQ. f0 In GHz"
770  IF C$="3"  THEN INPUT f0 : PRINT : PRINT " 3. f0=";f0;"GHz" : GOTO 1090
780  IF C$="4"  THEN PRINT : PRINT " ENTER THE RF LOSSES Lp IN db"
790  IF C$="4"  THEN INPUT Lp : PRINT : PRINT " 4. Lp=";Lp;"db" : GOTO 1090
800  IF C$="5"  THEN PRINT : PRINT " ENTER THE RECEIVER NOISE BANDWIDTH Bn IN MHz"
820  IF C$="5"  THEN INPUT Bn : PRINT : PRINT " 5. Bn=";Bn;"MHz" : GOTO 1090
830  IF C$="6"  THEN PRINT : PRINT " ENTER THE RECEIVER NOISE FIGURE F IN db"
840  IF C$="6"  THEN INPUT F : PRINT : PRINT " 6. F=";f;"db" : GOTO 1090
850  IF C$="7"  THEN PRINT : PRINT " ENTER THE PULSE WIDTH T  IN ns"
860  IF C$="7"  THEN INPUT T : PRINT : PRINT " 7. T=";T;"ns" : GOTO 1090
870  IF C$="8"  THEN PRINT : PRINT " ENTER THE P.R.F fp IN KHz"
880  IF C$="8"  THEN INPUT fp : PRINT : PRINT " 8. fp=";fp;"KHz" : GOTO 1090
890  IF C$="9"  THEN PRINT : PRINT " ENTER THE INTEGRATION TIME T1 IN msec."
900  IF C$="9"  THEN INPUT T1 : PRINT : PRINT " 9. T1=";T1;"msec." : GOTO 1090
910  IF C$="10" THEN PRINT : PRINT "ENTER THE WEATHER ATTENUATION At IN db/KM"
920  IF C$="10" THEN INPUT At : PRINT : PRINT " 10. At=";At;"db/KM" : GOTO 1090
930  IF C$="11" THEN PRINT : PRINT " ENTER THE SKY TEMPERATURE Ta IN KELVIN"
940  IF C$="11" THEN INPUT Ta : PRINT : PRINT " 11. Ta=";Ta;"KELVIN" : GOTO 1090
950  IF C$="12" THEN PRINT : PRINT " ENTER THE TARGET RCS IN dbsm"
960  IF C$="12" THEN INPUT RCS : PRINT : PRINT " 12. RCS=";RCS;"dbsm" : GOTO 1090
970  IF C$="13" THEN PRINT : PRINT " ENTER THE DEG. OF THE PENCIL BEAM PB (part b)"
980  IF C$="13" THEN INPUT PB : PRINT : PRINT " 13. PB=";PB;"Deg." : GOTO 1090
990  IF C$="14" THEN PRINT : PRINT " ENTER THE (J/S) JS IN db (part b)"
1000 IF C$="14" THEN INPUT JS : PRINT : PRINT " 14. (J/S)=";JS;"db" : GOTO 1090
1010 IF C$="15" THEN PRINT : PRINT " ENTER THE RANGE R IN KM (part c)"
1020 IF C$="15" THEN INPUT R : PRINT : PRINT " 15. R=";R;"KM" : GOTO 1090
1030 IF C$="16" THEN PRINT : PRINT " ENTER THE RF LOSSES RFL IN db (part d)"
1040 IF C$="16" THEN INPUT RFL : PRINT : PRINT " 16. RFL=";RFL;"db" GOTO 1090
1050 IF C$="17" THEN PRINT : PRINT " ENTER THE ILLUMINATION EFFICIENCY r1 (part d)"
1060 IF C$="17" THEN INPUT r1 : PRINT : PRINT " 17. r1=";r1 : GOTO 1090
1070 IF C$="18" THEN PRINT : PRINT " ENTER THE CROSSOVER LOSSE Lco IN db"
```

```
1080  IF C$="18" THEN INPUT Lco : PRINT : PRINT " 18. Lco=";Lco;"db" : GOTO 1090
1090  PRINT : PRINT " IS EVERYTHING O.K NOW?"
1100  INPUT B$
1110  IF LEFT$(B$,1)="Y" OR LEFT$(B$,1)="y"   THEN 1150
1120  PRINT : PRINT " WHAT DO YOU WANT TO CHANGE AGAIN?"
1130  PRINT : PRINT " HIT ANY KEY IN YOUR KEYBOARD AND EVERYTHING WILL WORK FOR YOU
MALAKA"
1140  INPUT F$   : GOTO 530
1150  RETURN
1160 '*********************************
1170  '      PRINTS THE INPUT DATA
1180 '*********************************
1190  LPRINT : LPRINT TAB(30); " PROBLEM #3"
1200  LPRINT TAB(30); " ----------"
1210  LPRINT : LPRINT " G I V E N"
1220  LPRINT " ---------"
1230  LPRINT : LPRINT " 1. Pt=";Pt;"W" SPC(10); " : OUTPUT PEAK POWER"
1240  LPRINT : LPRINT " 2. Gt=";Gt;"db" SPC(8); " : BORESIGHT ANTENNA GAIN"
1250  LPRINT : LPRINT " 3. f0=";f0;"GHz" SPC(5); " : OPERATING FREQ."
1260  LPRINT : LPRINT " 4. Lp=";Lp;"db" SPC(9); " : RF LOSSES"
1270  LPRINT : LPRINT " 5. Bn=";Bn;"MHz" SPC(6); " : RECEIVER NOISE BANDWIDTH"
1280  LPRINT : LPRINT " 6. F=";f;"db" SPC(9); " : RECEIVER NOISE FIGURE"
1290  LPRINT : LPRINT " 7. T=";T;"ns" SPC(9); " : PULSE WIDTH"
1300  LPRINT : LPRINT " 8. fp=";fp;"KHz" SPC(6); " : P.R.F"
1310  LPRINT : LPRINT " 9. T1=";T1;"msec." SPC(5); " : INTEGRATION TIME"
1320  LPRINT : LPRINT " 10. At=";At;"db/KM" SPC(4); " : WEATHER ATTENUATION"
1330  LPRINT : LPRINT " 11. Ta=";Ta;"KELVIN" SPC(2); " : SKY TEMPERATURE"
1340  LPRINT : LPRINT " 12. RCS=";RCS;"dbsm" SPC(2); " : TARGET RCS"
1350  LPRINT : LPRINT " 13. PB=";PB;"Deg." SPC(5); " : DEG. OF THE PENCIL BEAM"
1360  LPRINT : LPRINT " 14. (J/S)=";JS;"db" SPC(4); " : (J/S)"
1370  LPRINT : LPRINT " 15. R=";R;"KM" SPC(9); " : RANGE"
1380  LPRINT : LPRINT " 16. RFL=";RFL;"db" SPC(7); " : RF LOSSES for part d"
1390  LPRINT : LPRINT " 17. r1=";r1 SPC(9); " : ILLUMINATION EFFICIENCY"
1400  LPRINT : LPRINT " 18. Lco=";Lco;"db" SPC(7); " : CROSSOVER LOSS"
1410  RETURN
```

```
1420 '*****************************************
1430  ' SUBRUTINE THAT CONVERTS UNITS
1440 '*****************************************
1450  LET M=.4342945#
1460  LET PI=3.14159 :  C=3*10^8
1470  LET f0=f0*10^9 : fp=fp*10^3
1480  LET R=R*10^3 : l=C/f0
1490  LET Gt1=Gt/10:Gt2=CINT(10^Gt1)
1500  LET Lp1=Lp/10:Lp2=10^Lp1
1510  LET RCS1=RCS/10:RCS2=CSNG(10^RCS1)
1520  LET ra=10^(-1/10)
1530  LET Gtot=Gt+RFL:Gtot1=Gtot/10:Gtot2=CINT(10^Gtot1)
1540  LET Lco1=Lco/10:Lco2=CSNG(10^(-Lco1))
1550  LET Gd=Gt+RFL+Lco
1560  LET Gd1=Gd/10:Gd2=10^Gd1
1570  RETURN
1580 '****************************************
1590  ' PRINTS THE RESULTS
1600 '****************************************
1610  PRINT:PRINT:PRINT " PART (a):"
1620  PRINT "----------"
1630  LPRINT:LPRINT:LPRINT " PART (a):"
1640  LPRINT "----------"
1650  LET Ru=c/(2*fp)*(1/1000)
1660  PRINT:PRINT " a. Ru=";Ru;"KM"; ": MAX. UNAMBIGUOUS RANGE"
1670  LPRINT:LPRINT " a. Ru=";Ru;"KM"; ": MAX. UNAMBIGUOUS RANGE"
1680  PRINT:PRINT:PRINT " PART (b):"
1690  PRINT "----------"
1700  LPRINT:LPRINT:LPRINT " PART (b):"
1710  LPRINT "----------"
1720  LET G=41250l/(PB^2) : Ae=l^2*G/(4*PI)
1730  LET Ge=JS*(Lp2^2)*RCS2/(Ae*G)
1740  LET Ge1=CSNG(10*M*LOG(Ge))
1750  PRINT:PRINT " b. Ge=";Ge1; "db"; ": REPEATER GAIN REQUIRED FOR (J/S)=";JS;"db"
1760  LPRINT:LPRINT " b. Ge=";Ge1;"db"; ": REPEATER GAIN REQUIRED FOR (J/S)=";JS;"db"
```

```
1770 PRINT : PRINT : PRINT " PART (c) :"
1780 PRINT "----------"
1790 LPRINT : LPRINT : LPRINT " PART (c) :"
1800 LPRINT "----------"
1810 LET Pout=Pt*Gt2*(10^(-At/10))*Ae*Ge/(4*PI*R^2*Lp2)
1820 LET Pout=CSNG(Pout*1000)     'mW
1830 PRINT : PRINT " c. Pout=";Pout;"mW"; " : JAMMER OUTPUT POWER"
1840 LPRINT : LPRINT " c. Pout=";Pout;"mW"; " : JAMMER OUTPUT POWER"
1850 PRINT : PRINT : PRINT " PART (d) :"
1860 PRINT "----------"
1870 LPRINT : LPRINT : LPRINT " PART (d) :"
1880 LPRINT "----------"
1890 LET D=CSNG(1/PI*SQR(Gtot2/(ra*r1))*100)    'cm
1900 PRINT : PRINT " d. D=";D;"cm"; " : DIAMETER OF THE SEEKER DISH ANTENNA"
1910 LPRINT : LPRINT " d. D=";D;"cm"; " : DIAMETER OF THE SEEKER DISH ANTENNA"
1920 PRINT : PRINT : PRINT " PART (e) :"
1930 PRINT "----------"
1940 LPRINT : LPRINT : LPRINT " PART (e) :"
1950 LPRINT "----------"
1960 LET THb=SQR(41253!/Gd2)
1970 LET THq=((LOG(Lco2))/(-2.776))^(1/2)*THb:THq=CSNG(THq)
1980 PRINT : PRINT " e. THq=";THq;"Deg."; " : SQUINT ANGLE"
1990 LPRINT : LPRINT " e. THq=";THq;"Deg."; " : SQUINT ANGLE"
2000 RETURN
```

PROBLEM#3

GIVEN

1. Pt= 1 W	: OUTPUT PEAK POWER
2. Gt= 38 db	: BORESIGHT ANTENNA GAIN
3. f0= 93.7 GHz	: OPERATING FREQ.
4. Lp= 3 db	: RF LOSSES
5. Bn= 500 MHz	: RECEIVER NOISE BANDWIDTH
6. F= 11 db	: RECEIVER NOISE FIGURE
7. T= 50 ns	: PULSE WIDTH
8. fp= 100 KHz	: P.R.F
9. Ti= 50 msec.	: INTEGRATION TIME
10. At= .4 db/KM	: WEATHER ATTENUATION
11. Ta= 270 KELVIN	: SKY TEMPERATURE
12. RCS= 14.8 dbsm	: TARGET RCS
13. PB= 10 Deg.	: DEG. OF THE PENCIL BEAM
14. (J/S)= 10 db	: (J/S)
15. R= 1 KM	: RANGE
16. RFL= 1 db	: RF LOSSES for part d
17. η= .6	: ILLUMINATION EFFICIENCY
18. Lco= 1 db	: CROSSOVER LOSS

PART (a):

a. Ru= 1.5 KM : MAX. UNAMBIGUOUS RANGE

PART (b):

b. Ge= 39.376 db : REPEATER GAIN REQUIRED FOR (J/S)= 10 db

PART (c):

c. Pout= .658953 mW : JAMMER OUTPUT POWER

PART (d):

D= 13.1568 cm : DIAMETER OF THE SEEKER DISH ANTENNA

PART (e):

e. THq= .58496 Deg. : SQUINT ANGLE

```
10    PRINT : PRINT TAB(30); " PROBLEM #4"
20    PRINT TAB(30); "---------"
30    GOSUB 100 : GOSUB 1050 : GOSUB 1300
40    GOSUB 1480 : GOSUB 1640 : GOSUB 1800 : GOSUB 1960
50    PRINT : PRINT " DO YOU WANT TO TRY AGAIN FOR DIFFERENT OR THE SAME DATA Y/N?"
60     INPUT D$
70    IF LEFT$(D$,1)="Y" OR LEFT$(D$,1)="y"  THEN 30
80     END
90    '**********************************
100   '          INPUTS THE DATA
110   '**********************************
120   PRINT : PRINT " ENTER THE ARRAY SIZE d1,d2 IN METERS"
130   INPUT d1,d2 : PRINT : PRINT " 1. d1xd2=";d1"x"d2" m"
140   PRINT : PRINT " ENTER THE OPERATING FREQ. f0 IN GHz"
160    INPUT f0 : PRINT : PRINT " 2. f0=";f0;"GHZ"
170   PRINT : PRINT " ENTER THE FEED & PHASE SHIFTER LOSSES Lfp IN db"
180   INPUT Lfp : PRINT : PRINT " 3. Lfp=";Lfp;"db"
190   PRINT : PRINT " ENTER THE SIDELOBE LEVEL S.L IN db"
200   INPUT S.L : PRINT : PRINT " 4. S.L=";S.L;"db"
210   PRINT : PRINT " ENTER THE ILLUMINATION EFFICIENCY n1"
220    INPUT n1 : PRINT : PRINT " 5. n1=";n1
230   PRINT : PRINT " ENTER THE OUTPUT POWER Pa IN Mw"
240    INPUT Pa : PRINT : PRINT " 6. Pa=";Pa;"Mw"
250   PRINT : PRINT " ENTER THE VALUE OF THE TWO T.W"
260    INPUT T.W : PRINT : PRINT " 7. T.W=";T.W
270   PRINT : PRINT " ENTER THE WEIGHTING FILTER LOSS Lm IN db"
280   INPUT Lm : PRINT : PRINT " 8. Lm=";Lm;"db"
290   PRINT : PRINT " ENTER THE VALUE OF THE MIN. OUTPUT FOR AUTOMATIC DETECTION,S1 IN
 db"
```

```
300  INPUT S1: PRINT : PRINT " 9. (S/N)min=";S1;"db"
310  PRINT : PRINT " ENTER THE R.C.S OF THE CRUISE MISSILES Sav IN dbsm"
320  INPUT Sav : PRINT : PRINT " 10. Sav=";Sav;"dbsm"
330  PRINT : PRINT " ENTER THE RANGE OF THE TWO NOISE JAMMERS R IN KM"
340  INPUT R : PRINT : PRINT " 11. R=";R;"KM"
350  PRINT : PRINT " ENTER THE #OF CARCINOTRONS THAT EACH JAMMER CARRIES Cr"
360  INPUT Cr : PRINT : PRINT " 12. Cr=";Cr
370  PRINT : PRINT " ENTER THE ERP Pj IN KW"
380  INPUT Pj : PRINT : PRINT " 13. Pj=";Pj;"KW/tube"
390  PRINT : PRINT " ENTER THE PROPAGATION FACTOR g"
400  INPUT g : PRINT : PRINT " 14. g=";g
410  PRINT : PRINT "NOW GO TO PART c&e OF THE PROBLEM AND ENTER THE FOLLOWING :"
420  PRINT : PRINT " ENTER THE RANGE THAT THE CRUISE MISSILE IS ILLUMINATED R1 IN KM"
430  INPUT R1 : PRINT : PRINT " 15. R1=";R1;"KM"
450  PRINT : PRINT " ENTER AGAIN THE RANGE THAT THE CRUISE MISSILE IS ILLUMINATED R2 IN
 KM (for part e)"
460  INPUT R2 : PRINT : PRINT " 16. R2=";R2;"KM"
470  PRINT : PRINT " ENTER THE INTEGRATION EFFICIENCY E1"
480  INPUT E1 : PRINT : PRINT " 17. E1(n)=";E1
490  PRINT : PRINT " IS THE INPUT DATA CORRECT Y/N?"
500  INPUT A$
510  IF LEFT$(A$,1)="Y" OR LEFT$(A$,1)="y" THEN 1030
520  PRINT : PRINT " WHAT OF THE FOLLOWING DO YOU WANT TO CHANGE?"
530  PRINT : PRINT " 1. THE SIZE OF THE ARRAY?", " 2. THE OPERATING FREQ.?"
540  PRINT : PRINT " 3. THE FEED AND PHASE SHIFTER LOSSES?", " 4. THE SIDELOBE LEVEL?"
550  PRINT : PRINT " 5. THE ILLUMINATION EFFICIENCY?", " 6. THE OUTPUT POWER?"
560  PRINT : PRINT " 7. THE VALUE OF THE TWO TW?", " 8. THE WEIGHTING FILTER LOSS?"
570  PRINT : PRINT " 9. THE VALUE OF THE (S/N)min?", " 10. THE RCS OF THE CRUISE MISSILE?"
580  PRINT : PRINT " 11. THE RANGE OF THE TWO NOISE JAMMERS?",
```

```
590   PRINT : PRINT " 12. THE #OF CANCINOTRONS?", " 13. THE ERP?"
600   PRINT : PRINT " 14. THE PROPAGATION FACTOR?", " 15. THE RANGE OF THE CRUISE MISSILE
 (part c)?"
610   PRINT : PRINT " 16. THE RANGE OF THE CRUISE MISSILE (part e)?", " 17. THE INTEGRATION
 EFFICIENCY?"
620   INPUT C$
630   IF C$="1"  THEN   PRINT : PRINT " ENTER THE ARRAY SIZE d1,d2 IN METERS"
640   IF C$="1"  THEN   INPUT d1,d2 : PRINT : PRINT " 1. d1xd2=";d1"x"d2" m" : GOTO 970
650   IF C$="2"  THEN   PRINT : PRINT " ENTER THE OPERATING FREQ. f0 IN GHz"
660   IF C$="2"  THEN   INPUT f0 : PRINT : PRINT " 2. f0=";f0;"GHZ" : GOTO 970
670   IF C$="3"  THEN   PRINT : PRINT " ENTER THE FEED & PHASE SHIFTER LOSSES Lfp IN db"
680   IF C$="3"  THEN   INPUT Lfp : PRINT : PRINT " 3. Lfp=";Lfp;"db" : GOTO 970
690   IF C$="4"  THEN   PRINT : PRINT " ENTER THE SIDELOBE LEVEL S.L IN db"
700   IF C$="4"  THEN   INPUT S.L : PRINT : PRINT " 4. S.L=";S.L;"db" : GOTO 970
710   IF C$="5"  THEN   PRINT : PRINT " ENTER THE ILLUMINATION EFFICIENCY r1"
720   IF C$="5"  THEN   INPUT r1 : PRINT : PRINT " 5. r1=";r1 : GOTO 970
730   IF C$="6"  THEN   PRINT : PRINT " ENTER THE OUTPUT POWER Pa IN Mw"
740   IF C$="6"  THEN   INPUT Pa : PRINT : PRINT " 6. Pa=";Pa;"Mw" : GOTO 970
750   IF C$="7"  THEN   PRINT : PRINT " ENTER THE VALUE OF THE TWO T.W"
760   IF C$="7"  THEN   INPUT T.W : PRINT : PRINT " 7. T.W=";T.W : GOTO 970
770   IF C$="8"  THEN   PRINT : PRINT " ENTER THE WEIGHTING FILTER LOSS Lm IN db"
780   IF C$="8"  THEN   INPUT Lm : PRINT : PRINT " 8. Lm=";Lm;"db" : GOTO 970
790   IF C$="9"  THEN   PRINT : PRINT " ENTER THE VALUE OF THE MIN. OUTPUT FOR
 AUTOMATICDETECTION,S1 IN db"
800   IF C$="9"  THEN   INPUT S1: PRINT : PRINT " 9. (S/N)min=";S1;"db" : GOTO 970
810   IF C$="10" THEN   PRINT : PRINT " ENTER THE R.C.S OF THE CRUISE MISSILES Sav IN
 dbsm"
820   IF C$="10" THEN   INPUT Sav : PRINT : PRINT " 10. Sav=";Sav;"dbsm" : GOTO 970
830   IF C$="11" THEN   PRINT : PRINT " ENTER THE RANGE OF THE TWO NOISE JAMMERS R IN
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```
KM"
840  IF C$="11" THEN   INPUT R : PRINT : PRINT " 11. R=";R;"KM" : GOTO 970
850  IF C$="12" THEN   PRINT : PRINT " ENTER THE #OF CARCINOTRONS THAT EACH JAMMER
CARRIESCr"
860  IF C$="12" THEN   INPUT Cr : PRINT : PRINT " 12. Cr=";Cr : GOTO 970
870  IF C$="13" THEN   PRINT : PRINT " ENTER THE ERP PJ IN KW"
880  IF C$="13" THEN   INPUT PJ : PRINT : PRINT " 13. PJ=";PJ;"KW/tube" : GOTO 970
890  IF C$="14" THEN   PRINT : PRINT " ENTER THE PROPAGATION FACTOR g"
900  IF C$="14" THEN   INPUT g : PRINT : PRINT " 14. g=";g : GOTO 970
910  IF C$="15" THEN   PRINT : PRINT " ENTER THE RANGE THAT THE CRUISE MISSILE IS
ILLUMINATED R1 IN KM"
920  IF C$="15" THEN   INPUT R1 : PRINT : PRINT " 15. R1=";R1;"KM" : GOTO 970
930  IF C$="16" THEN   PRINT : PRINT " ENTER AGAIN THE RANGE THAT THE CRUISE MISSILE
IS ILLUMINATED R2 IN KM (for part e)"
940  IF C$="16" THEN   INPUT R2 : PRINT : PRINT " 16. R2=";R2;"KM" : GOTO 970
950  IF C$="17" THEN   PRINT : PRINT " ENTER THE INTEGRATION EFFICIENCY E1"
960  IF C$="17" THEN   INPUT E1 : PRINT : PRINT " 17. E1(n)=";E1 : GOTO 970
970  PRINT : PRINT " IS EVERYTHING O.K NOW?"
980  INPUT B$
990  IF LEFT$(B$,1)="Y" OR LEFT$(B$,1)="y" THEN 1030
1000 PRINT : PRINT " WHAT DO YOU WANT TO CHANGE AGAIN?"
1010 PRINT : PRINT " HIT ANY KEY IN YOUR KEYBOARD AND EVERYTHING WILL WORK FOR YOU
MALAKA"
1020 INPUT F$  : GOTO 530
1030 RETURN
1040'**********************************
1050 '     PRINTS THE INPUT DATA
1060'**********************************
1070 LPRINT : LPRINT TAB(30); " PROBLEM #4"
```

```
1080 LPRINT TAB(30);" ----------"
1090 LPRINT : LPRINT " G I V E N"
1100 LPRINT "---------"
1110 LPRINT : LPRINT " 1. d1xd2=";d1"x"d2" m" TAB(20); " : ARRAY SIZE"
1120 LPRINT : LPRINT " 2. f0=";f0;"GHZ"TAB(20);" : OPERATING FREQ."
1130 LPRINT : LPRINT " 3. Lfp=";Lfp;"db" TAB(20);" : FEED & PHASE SHIFTER LOSSES"
1140 LPRINT : LPRINT " 4. S.L=";S.L;"db" TAB(20);" : SIDELOBE LEVEL"
1150 LPRINT : LPRINT "5. rl=";rl TAB(20); " : ILLUMINATION EFFICIENCY"
1160 LPRINT : LPRINT "6. Pe=";Pe;"Mw" TAB(20);" : OUTPUT POWER"
1170 LPRINT : LPRINT "7. T.W=";T.W TAB(20);" : VALUE OF THE TWO TW"
1180 LPRINT : LPRINT " 8. Lm=";Lm;"db" TAB(20);" : WEIGHTING FILTER LOSS"
1190 LPRINT : LPRINT "9. (S/N)min=";S1;"db" TAB(20);" : (S/N)min FOR AUT. DETECTION"
1200 LPRINT : LPRINT " 10. Sav=";Sav;"dbsm" TAB(20);" : R.C.S FOR THE CRUISE MISSILE"
1210 LPRINT : LPRINT " 11. R=";R;"KM" TAB(20); " : RANGE OF THE TWO NOISE JAMMERS"
1220 LPRINT : LPRINT " 12. Cr=";Cr TAB(20); " : #OF CANCINOTRONS"
1230 LPRINT : LPRINT " 13. Pj=";Pj;"KW/tube" TAB(20);" : ERP VALUE"
1240 LPRINT : LPRINT " 14. g=";g TAB(20); " : PROPAGATION FACTOR"
1250 LPRINT : LPRINT " 15. R1=";R1;"KM" TAB(20); " : RANGE OF THE CRUISE MISSILE (part c)"
1260 LPRINT : LPRINT " 16. R2=";R2;"KM" TAB(20); " : RANGE OF THE CRUISE MISSILE (part e)"
1270 LPRINT : LPRINT " 17. E1(n)=";E1 TAB(20); " : INTEGRATION EFFICIENCY"
1280 RETURN
1290'****************************************
1300 ' CALCULATION AND PRINTOUT FOR PART e:
1310'****************************************
1320 PRINT : PRINT : PRINT " PART e:"
1330 LPRINT : LPRINT : LPRINT " PART e:"
1340 PRINT "-------"
1350 LPRINT "-------"
1360 LET PI=3.14159 : f0=f0*10^9 : C=3*10^8
```

```
1370 LET A=d1*d2
1380 LET 1=C/f0
1390 LET Lfp1=10^(-Lfp/10)
1400 LET Ae=CSNG(A*Lfp1*r1)
1410 LET Gp=CINT(4*PI*Ae/(1^2))
1420 PRINT : PRINT " 1(a). Ae=A*Lfp1*r1=";Ae;"sq.m"; " : EFFECTIVE AREA OF THE PHASED
 ARRAY"
1430 LPRINT : LPRINT " 1(a). Ae=A*Lfp1*r1=";Ae;"sq.m";" : EFFECTIVE AREA OF THE PHASED
 ARRAY"
1440 PRINT : PRINT " 2(a). Gp=4*PI*Ae/(1^2)=";Gp; " : POWER GAIN OF PHASED ARRAY"
1450 LPRINT : LPRINT " 2(a). Gp=4*PI*Ae/(1^2)=";Gp; " : POWER GAIN OF PHASED ARRAY"
1460 RETURN
1470'****************************************
1480 ' CALCULATION AND PRINTOUT FOR PART b:
1490'****************************************
1500 PRINT : PRINT : PRINT " PART b:"
1510 LPRINT : LPRINT : LPRINT " PART b:"
1520 PRINT " -------"
1530 LPRINT " -------"
1540 LET Pj=Pj*10^3
1550 LET Lm1=Lm/10 : Lm2=10^Lm1
1560 LET R=R*10^3
1570 LET J=CSNG(2*Cr*Pj*Ae/(4*PI*R^2*Lm2*T.W))
1580 LET J1=CSNG(10*.4342945*LOG(J)) 'dbw VALUE
1590 LET J2=CSNG(J1+30)         'dbm VALUE
1600 PRINT:PRINT " 1(b).J=Gj*Pj**Ae/(4*PI*R^2*Lm2*T.W)=";J;"W";" OR";J1;"dbw";" OR
 ";J2;"dbm"
1610 LPRINT :LPRINT " 1(b).J=Gj*Pj**Ae/(4*PI*R^2*Lm2)=";J;"W";"OR";J1;"dbw";"
 OR";J2;"dbm"
```

```
1620 RETURN
1630'**************************************
1640 ' CALCULATION AND PRINTOUT FOR PART c:
1650'**************************************
1660 PRINT : PRINT : PRINT " PART c:"
1670 LPRINT : LPRINT : LPRINT " PART c:"
1680 PRINT "-------"
1690 LPRINT "-------"
1700 LET Pa=Pa*10^6
1710 LET S1av=10^(-Sav/10)
1720 LET R1=R1*10^3
1730 LET S2=CSNG(Pa*Gp*S1av*Ae/((4*PI*R1^2)^(2)))
1740 LET S3=CSNG(10*.4342945**LOG(S2))    'dbw
1750 LET S4=CSNG(S3+30)   'dbm
1760 PRINT :PRINT" 1(c). S=Pa*Gp*S1av*Ae/((4*PI*R1^2)^(2))=";S2;"W";" OR";S3,"dbw"," OR
 ";S4;"dbm";" : SINGLE PULSE ECHO SIGNAL POWER"
1770 LPRINT :LPRINT " 1(c). S=Pa*Gp*S1av*Ae/((4*PI*R1^2)^(2))=";S2;"W";" OR";S3;"dbw";"
 OR";S4;"dbm";" : SINGLE PULSE ECHO SIGNAL POWER"
1780 RETURN
1790'**************************************
1800 ' CALCULATION AND PRINTOUT FOR PART d:
1810'**************************************
1820 PRINT : PRINT : PRINT " PART d:"
1830 LPRINT : LPRINT : LPRINT " PART d:"
1840 PRINT "-------"
1850 LPRINT "-------"
1860 LET T.W1=10*.4342945**LOG(T.W)
1870 LET B=CSNG(J2-S4)
1880 LET C=CSNG(-B+T.W1-Lm)
```

```
1890 LET C=-C
1900 PRINT : PRINT " 1(d). (J/S)In=J2-S4=";B;"dbm";" : THE SINGLE PULSE (J/S) AT THE
 RECEIVERINPUT"
1910 LPRINT : LPRINT " 1(d). (J/S)In=J2-S4=";B;"dbm";" : THE SINGLE PULSE (J/S) AT THE
 RECEIVERINPUT"
1920 PRINT : PRINT " 2(d). (S/J)out=(S/J)In+(T.W)-Lm=";C;"db";" : THE SINGLE PULSE (J/S) AT
 THERECEIVER OUTPUT"
1930 LPRINT : LPRINT " 2(d). (S/J)out=(S/J)In+(T.W)-Lm=";C;"dbm";" : THE SINGLE PULSE (J/S)
 AT THE RECEIVER OUTPUT"
1940 RETURN
1950'****************************************
1960 ' CALCULATION AND PRINTOUT FOR PART e:
1970'****************************************
1980 PRINT : PRINT : PRINT " PART e:"
1990 LPRINT : LPRINT : LPRINT " PART e:"
2000 PRINT " -------"
2010 LPRINT " -------"
2020 LET I1=S1+C
2030 LET I11=I1/10 : I12=10^I11
2040 PRINT : PRINT " 1(e). I1(n)=n=";CINT(I12);" : #OF PULSES INTEGR. IN PERFECT INTEGRATOR"
2050 LPRINT : LPRINT " 1(e). I1(n)=n=";CINT(I12);" : #OF PULSES INTEGR. IN PERFECT
 INTEGRATOR"
2060 RETURN
```

PROBLEM*4

GIVEN

1. d1xd2= 3.65 x 3.65 m : ARRAY SIZE
2. f0= 3.3 GHZ : OPERATING FREQ.
3. Lfp= 2.5 db : FEED & PHASE SHIFTER LOSSES
4. S.L= 30 db : SIDELOBE LEVEL
5. n= .5 : ILLUMINATION EFFICIENCY
6. Pa= 4 MW : OUTPUT POWER
7. T.W= 1000 : VALUE OF THE TWO TW
8. Lm= 3 db : WEIGHTING FILTER LOSS
9. (S/N)min= 13 db : (S/N)min FOR AUT. DETECTION
10. Sav= 3 dbsm : R.C.S FOR THE CRUISE MISSILE
11. R= 100 KM : RANGE OF THE TWO NOISE JAMMERS
12. Cr= 18 : *OF CANCINOTRONS
13. Pj= 10 KW/tube : ERP VALUE
14. g= 1 : PROPAGATION FACTOR
15. R1= 80 KM : RANGE OF THE CRUISE MISSILE (part c)
16. R2= 80 KM : RANGE OF THE CRUISE MISSILE (part e)
17. E1(n)= 1 : INTEGRATION EFFICIENCY

PART a:

1(a). Ae=A*Lfp1*n=3.7459 sq.m: EFFECTIVE AREA OF THE PHASED ARRAY

2(a). Gp=4*PI*Ae/(l^2)= 5696 : POWER GAIN OF PHASED ARRAY

PART b:

1(b). J=Gj*Pj**Ae/(4*PI*R^2*Lm2*T.W)=5.37835 E-09 W OR -82.6935 dbw OR -52.6935 dbm

PART c:

1(c). S=Pa*Gp*S1av*Ae/((4*PI*R1^2)^(2))= 6.613130-12 W OR -111.796 dbw OR -81.796 dbm
SINGLE PULSE ECHO SIGNAL POWER

PART d:

1(d). (J/S)in=J2-S4= 29.1025 dbm : THE SINGLE PULSE (J/S) AT THE RECEIVER INPUT

2(d). (S/J)out=(S/J)in+(T.W)-Lm= 2.1025 db : THE SINGLE PULSE (J/S) AT THE RECEIVER OUTPUT

PART e:

1(e). II(n)=n= 32 : # OF PULSES INTEGR. IN PERFECT INTEGRATOR

```
10   PRINT : PRINT TAB(30) " PROBLEM #5 "
20   PRINT TAB(30); " ---------"
30   GOSUB 100 : GOSUB 1120 : GOSUB 1480
40   GOSUB 1680
50   PRINT : PRINT " DO YOU WANT TO TRY AGAIN FOR DIFFERENT OR THE SAME DATA Y/N?"
60   INPUT D$
70   IF LEFT$(D$,1)="Y" OR LEFT$(D$,1)="y"  THEN 30
80   END
90   '********************************
100  '          INPUTS THE DATA
110  '********************************
120  PRINT : PRINT " ENTER THE  OPERATING FREQ f0 IN GHz""
130  INPUT f0 : PRINT : PRINT "  1. f0=";f0;"GHz"
140  PRINT : PRINT " ENTER THE PEAK POWER Pa IN KW"
150  INPUT Pa : PRINT : PRINT " 2. Pa=";Pa;"KW"
160  PRINT : PRINT " ENTER THE ANTENNA MAIN BEAM GAIN Ga IN db"
170  INPUT Ga : PRINT : PRINT " 3. Ga=";Ga;"db"
180  PRINT : PRINT " ENTER THE  ANTENNA SIDELOBE GAIN Gp IN db"
190  INPUT Gp : PRINT : PRINT " 4. Gp=";Gp;"db"
200  PRINT : PRINT " ENTER THE P.R.F  IN MHz"
210  INPUT fp : PRINT : PRINT " 5. fp=";fp;"MHz"
220  PRINT : PRINT " ENTER THE PULSE WIDTH T IN micsec."
230  INPUT T : PRINT : PRINT " 6. T=";T;"micsec."
240  PRINT : PRINT " ENTER THE RECEIVER NOISE FIGURE F IN db"
250  INPUT F : PRINT : PRINT " 7. F=";F;"db"
260  PRINT : PRINT " ENTER THE RECEIVER NOISE BANDWIDTH Bn IN MHZ"
270  INPUT Bn : PRINT : PRINT " 8. Bn=";Bn;"MHz"
280  PRINT : PRINT " ENTER THE ANTENNA NOISE TEMPERATURE Ta IN KELVIN"
290  INPUT Ta : PRINT : PRINT " 9. Ta=";Ta;"KELVIN"
300  PRINT : PRINT " ENTER THE ANTENNA SECTOR COVERAGE Ss IN Deg."
310  INPUT Ss : PRINT : PRINT " 10. Ss=";Ss;"Deg."
320  PRINT : PRINT " ENTER THE ANTENNA SCAN RATE Sr"
330  INPUT Sr : PRINT : PRINT " 11. Sr=";Sr;"scans/sec"
340  PRINT : PRINT " ENTER THE OUTPUT POWER OF THE JAMMER Pj IN W"
350  INPUT Pj : PRINT : PRINT " 12. Pj=";Pj;"W"
```

```
360   PRINT : PRINT " ENTER THE RF NOISE BANDWIDTH OF THE JAMMER Brf IN MHz"
370   INPUT Brf : PRINT : PRINT " 13. Brf=";Brf;"MHz"
380   PRINT : PRINT " ENTER THE ANTENNA GAIN OF THE JAMMER Gj IN db"
390   INPUT Gj : PRINT : PRINT " 14. Gj=";Gj;"db"
400   PRINT : PRINT " ENTER THE RANGE WHERE THE JAMMER IS POSITIONED R IN KM"
410   INPUT R: PRINT : PRINT " 15. R=";R;"KM"
420   PRINT : PRINT " ENTER THE (J/S) RATIO J.S IN db"
430   INPUT J.S : PRINT : PRINT "16. J.S=";J.S;"db"
440   PRINT : PRINT " ENTER THE CAMOFLAGE FAC. .R CF IN db"
450   INPUT CF : PRINT : PRINT " 17. CF=";CF;"db"
460   PRINT : PRINT " ENTER THE PLUMBING LOSSES Lp IN db"
470   INPUT Lp : PRINT : PRINT " 18. Lp=";Lp;"db"
480   PRINT : PRINT " ENTER RANGE AT WHICH THE MORTOW ROUND PASSES THROUGH THE
 RADAR BEAM R1 IN KM"
490   INPUT R1 : PRINT : PRINT " 19. R1=";R1;"KM"
500   PRINT : PRINT " IS THE INPUT DATA CORRECT Y/N?"
510   INPUT A$
520   IF LEFT$(A$,1)="Y" OR LEFT$(A$,1)="y" THEN 1100
530   PRINT : PRINT " WHAT OF THE FOLLOWING DO YOU WANT TO CHANGE?"
540   PRINT :PRINT " 1. THE OPERATING FREQ.?"," 2. THE PEAK POWER?"
550   PRINT : PRINT " 3. THE ANTENNA MAIN BEAM GAIN?"," 4. THE ANTENNA SIDELOBE GAIN?"
560   PRINT : PRINT " 5. P.R.F?"," 6. THE PULSE WIDTH?"
570   PRINT : PRINT " 7. THE RECEIVER NOISE FIGURE?"," 8. THE RECEIVER NOISE BANDWIDTH?"
580   PRINT : PRINT " 9. THE ANTENNA NOISE TEMPERATURE?"," 10. THE ANTENNA SECTOR
 COVERAGE?"
590   PRINT : PRINT " 11. THE ANTENNA SCAN RATE?"," 12. THE JAMMER'S OUTPUT POWER?"
600   PRINT : PRINT " 13. THE JAMMER'S RF NOISE BANDWIDTH?"," 14. THE JAMMER'S ANTENNA
 GAIN?"
620   PRINT : PRINT " 15. THE RANGE POSITION OF THE JAMMER?"," 16. THE (J/S) OF THE
 JAMMER?"
630   PRINT : PRINT " 17. THE CAMOFLAGE FACTOR?"," 18. THE PLUMBING LOSSES?"
640   PRINT : PRINT " 19. THE RANGE AT WHICH THE MORTOW ROUND PASSES THROUGH THE
 RADARBEAM?"
650   INPUT C$
660   IF C$="1" THEN PRINT : PRINT " ENTER THE OPERATING FREQ f0 IN GHz""
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```
670  IF C$="1"  THEN INPUT f0 : PRINT : PRINT " 1. f0=";f0;"GHz" : GOTO 1040
680  IF C$="2"  THEN PRINT : PRINT " ENTER THE PEAK POWER Pa IN KW"
690  IF C$="2"  THEN INPUT Pa : PRINT : PRINT " 2. Pa=";Pa;"KW" : GOTO 1040
700  IF C$="3"  THEN PRINT : PRINT " ENTER THE ANTENNA MAIN BEAM GAIN Ga IN db"
710  IF C$="3"  THEN INPUT Ga : PRINT : PRINT " 3. Ga=";Ga;"db" : GOTO 1040
720  IF C$="4"  THEN PRINT : PRINT " ENTER THE  ANTENNA SIDELOBE GAIN Gp IN db"
730  IF C$="4"  THEN INPUT Gp : PRINT : PRINT " 4. Gp=";Gp;"db" : GOTO 1040
740  IF C$="5"  THEN PRINT : PRINT " ENTER THE P.R.F IN MHz"
750  IF C$="5"  THEN INPUT fp : PRINT : PRINT " 5. fp=";fp;"MHz" : GOTO 1040
760  IF C$="6"  THEN PRINT : PRINT " ENTER THE PULSE WIDTH T IN micsec."
770  IF C$="6"  THEN INPUT T : PRINT : PRINT " 6. T=";T;"micsec." : GOTO 1040
780  IF C$="7"  THEN PRINT : PRINT " ENTER THE RECEIVER NOISE FIGURE F IN db"
790  IF C$="7"  THEN INPUT F : PRINT : PRINT " 7. F=";F;"db" : GOTO 1040
800  IF C$="8"  THEN PRINT : PRINT " ENTER THE RECEIVER NOISE BANDWIDTH Bn IN MHZ"
810  IF C$="8"  THEN INPUT Bn : PRINT : PRINT " 8. Bn=";Bn;"MHz" : GOTO 1040
820  IF C$="9"  THEN PRINT : PRINT " ENTER THE ANTENNA NOISE TEMPERATURE Ta IN KELVIN"
830  IF C$="9"  THEN INPUT Ta : PRINT : PRINT " 9. Ta=";Ta;"KELVIN" : GOTO 1040
840  IF C$="10"  THEN PRINT : PRINT " ENTER THE ANTENNA SECTOR COVERAGE Ss IN Deg."
850  IF C$="10"  THEN INPUT Ss : PRINT : PRINT " 10. Ss=";Ss;"Deg." : GOTO 1040
860  IF C$="11"  THEN PRINT : PRINT " ENTER THE ANTENNA SCAN RATE Sr"
870  IF C$="11"  THEN INPUT Sr : PRINT : PRINT " 11. Sr=";Sr;"scans/sec" : GOTO 1040
880  IF C$="12"  THEN PRINT : PRINT " ENTER THE OUTPUT POWER OF THE JAMMER Pm IN W"
890  IF C$="12"  THEN INPUT Pj : PRINT : PRINT " 12. Pj=";Pj;"W" : GOTO 1040
900  IF C$="13"  THEN PRINT : PRINT " ENTER THE RF NOISE BANDWIDTH OF THE JAMMER Brf IN
 MHz"
910  IF C$="13"  THEN INPUT Brf : PRINT : PRINT " 13. Brf=";Brf;"MHz" : GOTO 1040
920  IF C$="14"  THEN PRINT : PRINT " ENTER THE ANTENNA GAIN OF THE JAMMER Gj IN db"
930  IF C$="14"  THEN INPUT Gj : PRINT : PRINT " 14. Gj=";Gj;"db" : GOTO 1040
940  IF C$="15"  THEN PRINT : PRINT " ENTER THE RANGE WHERE THE JAMMER IS POSITIONED R
 IN KM"
950  IF C$="15"  THEN INPUT R: PRINT : PRINT " 15. R=";R;"KM" : GOTO 1040
960  IF C$="16"  THEN PRINT : PRINT " ENTER THE (J/S) RATIO J.S IN db"
970  IF C$="16"  THEN INPUT J.S : PRINT : PRINT "16. J.S=";J.S;"db" : GOTO 1040
980  IF C$="17"  THEN PRINT : PRINT " ENTER THE CAMOFLAGE FACTOR CF IN db"
990  IF C$="17"  THEN INPUT CF : PRINT : PRINT " 17. CF=";CF;"db" : GOTO 1040
```

```
1000  IF C$="18"  THEN PRINT : PRINT " ENTER THE PLUMBING LOSSES Lp IN db"
1010  IF C$="18"  THEN INPUT Lp : PRINT : PRINT " 18. Lp=";Lp;"db" : GOTO 1040
1020  IF C$="19"  THEN PRINT : PRINT "  ENTER THE RANGE AT WHICH THE MORTOW ROUND
 PASSES THROUGH THE RADAR BEAM"
1030  IF C$="19"  THEN INPUT R1 : PRINT : PRINT " 19. R1=";R1;"KM" : GOTO 1040
1040  PRINT : PRINT " IS EVERYTHING O.K NOW?"
1050  INPUT B$
1060  IF LEFT$(B$,1)="Y" OR LEFT$(B$,1)="y"  THEN GOTO 1100
1070  PRINT : PRINT " WHAT DO YOU WANT TO CHANGE AGAIN?"
1080  PRINT : PRINT " HIT ANY KEY IN YOUR KEYBOARD AND EVERYTHING WILL WORK FOR YOU
 MALAKA"
1090  INPUT F$   : GOTO 540
1100  RETURN
1110'**********************************
1120 '      PRINTS THE INPUT DATA
1130'**********************************
1140  LPRINT : LPRINT TAB(30); " PROBLEM #5"
1150  LPRINT TAB(30);" ----------"
1160  LPRINT : LPRINT " G I V E N"
1170  LPRINT " ---------"
1180  LPRINT : LPRINT " 1. f0=";f0;"GHz" TAB(20); " : OPERATING FREQ "
1190  LPRINT : LPRINT " 2. Pa=";Pa;"KW" TAB(20); " : PEAK POWER"
1200  LPRINT : LPRINT " 3. Ga=";Ga;"db" TAB(20);" : ANTENNA MAIN BEAM GAIN"
1210  LPRINT : LPRINT " 4. Gp=";Gp;"db" TAB(20); " : ANTENNA SIDELOBE GAIN"
1220  LPRINT : LPRINT " 5. fp=";fp;"MHz" TAB(20); " : P.R.F"
1230  LPRINT : LPRINT " 6. T=";T;"micsec." TAB(20); " : PULSE WIDTH"
1240  LPRINT : LPRINT " 7. F=";F;"db" TAB(20);" : RECEIVER NOISE FIGURE"
1250  LPRINT : LPRINT " 8. Bn=";Bn;"MHz" TAB(20); " :RECEIVER NOISE BANDWIDTH"
1260  LPRINT : LPRINT " 9.Ta=";Ta;"KELVIN" TAB(20); " : ANTENNA NOISE TEMPERATURE
1270  LPRINT : LPRINT " 10. Ss=";Ss;"Deg." TAB(20); " : ANTENNA SECTOR COVERAGE"
1280  LPRINT : LPRINT " 11. Sr=";Sr;"scans/sec" TAB(20); " : ANTENNA SCAN RATE"
1290  LPRINT : LPRINT " 12. Pj=";Pj;"W" TAB(20); " : OUTPUT POWER OF THE JAMMER"
1300  LPRINT : LPRINT " 13. Brf=";Brf;"MHz" TAB(20); " : RF NOISE BANDWIDTH OF THE JAMMER"
1400  LPRINT : LPRINT " 14. Gj=";Gj;"db" TAB(20); " : ANTENNA GAIN OF THE JAMMER "
1410  LPRINT : LPRINT " 15. R=";R;"KM" TAB(20); " : RANGE WHERE THE JAMMER IS POSITIONED"
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```
1420 LPRINT : LPRINT " 16. J.S=";J.S;"db" TAB(20); " : (J/S) RATIO"
1430 LPRINT : LPRINT " 17. CF=";CF;"db" TAB(20); " : CAMOFLAGE FACTOR"
1440 LPRINT : LPRINT " 18. Lp=";Lp;"db" TAB(20); " : PLUMBING LOSSES"
1450 LPRINT : LPRINT " 19. R1=";R1;"KM"; TAB(20);" : RANGE AT WHICH THE MORTOW ROUND
 PASSES THROUGH THE RADAR BEAM"
1460 RETURN
1470********************************************
1480 ' CALCULATION & PRINTOUT FOR PART a:
1490********************************************
1500 PRINT : PRINT : PRINT " PART a:"
1510 PRINT " -------"
1520 LPRINT : LPRINT : LPRINT " PART a:"
1530 LPRINT " -------"
1540 LET Pj=Pj/Brf        'W/MHZ
1550 LET Gj1=Gj/10 : Gj2=CINT(10^Gj1)
1560 LET Lp1=Lp/10 : Lp2=CINT(10^Lp1)
1570 LET C=3*10^8 : f0=f0*10^9 : l=C/f0 : R=R*10^3
1580 LET PI=3.14159
1590 LET Gp1=Gp/10 : Gp2=CINT(10^Gp1)
1600 LET Ae=Gp2*l^2/(4*PI)
1610 LET J=CSNG(Pj*Gj2*Bn*Ae/(4*PI*R^2*Lp2))
1620 LET J1=CSNG(10*.4342945**LOG(J))
1630 LET J2=CSNG(J1+30)
1640 PRINT :PRINT " 1(a). J=Pj*Gj*Bn*Ae/(4*PI*R^2*Lp)=";J;"W";" OR";J1;"dbw";"
 OR";J2;"dbm"; " : NOISE JAMMING POWER"
1650 LPRINT : LPRINT " 1(a). J=Pj*Gj*Bn*Ae/(4*PI*R^2*Lp)=";J;"W";" OR";J1;"dbw";"
 OR";J2;"dbm"; " : NOISE JAMMING POWER"
1660 RETURN
1670********************************************
1680 ' CALCULATION & PRINTOUT FOR PART b:
1690********************************************
1700 PRINT : PRINT : PRINT " PART b:"
1710 PRINT " -------"
1720 LPRINT : LPRINT : LPRINT " PART b:"
1730 LPRINT " -------"
```

```
1740 LET J.S1=J.S/10:J.S2=CINT(10^J.S1)
1750 LET J.S3=0  'because CF=0
1760 LET J.S4=J.S3/10 : J.S5=10^J.S4
1780 LET R2=CINT(R1*((J.S5/J.S2)^(1/4)))
1790 PRINT :PRINT " 1(b).R2=(R1*((J/S)2/(J/S)1)^(1/4)))=";R2;"KM";" : RANGE AT WHICH THE
 ROUNDSBURNSTROUGH"
1800 LPRINT : LPRINT " 1(b).R2=(R1*((J/S)2/(J/S)1)^(1/4)))=";R2;"KM";" :RANGE AT WHICH
 THE ROUNDS BURNSTROUGH"
1810 RETURN
```

PROBLEM#5

GIVEN

1. f0= 16.1 GHz : OPERATING FREQ
2. Pa= 80 KW : PEAK POWER
3. Ga= 46 db : ANTENNA MAIN BEAM GAIN
4. Gp= 16 db : ANTENNA SIDELOBE GAIN
5. fp= 8600 MHz : P.R.F
6. T= .25 micsec. : PULSE WIDTH
7. F= 12 db : RECEIVER NOISE FIGURE
8. Bn= 5 MHz : RECEIVER NOISE BANDWIDTH
9. Ta= 290 KELVIN : ANTENNA NOISE TEMPERATURE
10. Ss= 25 Deg. : ANTENNA SECTOR COVERAGE
11. Sr= 167 scans/sec : ANTENNA SCAN RATE
12. Pj= 100 W : OUTPUT POWER OF THE JAMMER
13. Brf= 20 MHz : RF NOISE BANDWIDTH OF THE JAMMER
14. Gj= 23 db : ANTENNA GAIN OF THE JAMMER
15. R= 20 KM : RANGE WHERE THE JAMMER IS POSITIONED
16. J.S= 24 db . (J/S) RATIO
17. CF= 0 db : CAMOFLAGE FACTOR
18. Lp= 3 db : PLUMBING LOSSES
19. R1= 4 KM : RANGE AT WHICH THE MORTOW ROUND PASSES THROUGH THE RADAR BEAM

PART a:

1(a). J=Pj*Gj*Bn*Ae/(4*PI*R^2*Lp)= .549682 E-09 W OR -92.5989 dbw OR -62.5989 dbm : NOISEJAMMINGPOWER

PART b:

1(b). R2=(R1*((J/S)2/(J/S)1)^(1/4)))= 1 KM: RANGE AT WHICH THE ROUNDS BURNS TROUGH

```
10    PRINT : PRINT TAB(30); " PROBLEM #6"
20    PRINT TAB(30); " ----------"
30    LPRINT : LPRINT TAB(30); " PROBLEM #6"
40    LPRINT TAB(30); " ----------"
50    DIM F(4),l(4),Sav(4),N(4),V(4),m(4),m1(4),m2(4)
60    PRINT : PRINT " ENTER THE AVERAGE VALUE OF THE CLOUD CROSS SECTION S1 IN dbsm"
70    INPUT S1
80    PRINT : PRINT " ENTER THE CROSS SECTION OF THE INDIVIDUAL DIPOLES S2,S3 IN
 milinches"
90    INPUT S2,S3
100   PRINT : PRINT " ENTER THE STEP OF THE FREQ. f(1),f(2),...IN GHz"
110   INPUT f(1),f(2),f(3),f(4)
120   LET C=3*10^10          'cm/s
130   LET f(1)=f(1)*10^9 : f(2)=f(2)*10^9 : f(3)=f(3)*10^9 : f(4)=f(4)*10^9
140   LET S4=S2*S3*10^-6*(2.54)^2       'convertion from inches to cm.sq.
150   FOR I=1 TO 4
160   l(I)=C/f(I)
170   Sav(I)=.15*l(I)^2
180   N(I)= S1*100/Sav(I)
190   N(I)=CSNG(100* N(I))
200   V(I)=CSNG(S4*l(I)*N(I))
210   m(I)=CSNG(2.7*V(I))
220   m1(I)=CSNG(m(I)/S1)
230   m2(I)=CSNG(m(I)/(455*S1))
240   NEXT I
250   PRINT : PRINT " G I V E N"
260   PRINT " ---------"
270   LPRINT : LPRINT " G I V E N"
280   LPRINT " ---------"
290   PRINT : PRINT " a. S1=";S1;"dbsm"; " : AVERAGE VALUE OF THE CLOUD CROSS SECTION"
300   LPRINT : LPRINT " a. S1=";S1;"dbsm"; " : AVERAGE VALUE OF THE CLOUD CROSS SECTION"
310   PRINT : PRINT " b. S2xS3=";S2"x"S3;"mi.inch"; " : CROSS SECTIONAL DIMENSIONS OF THE
 INDIVIDUALDIPOLES"
320   LPRINT : LPRINT " b. S2xS3=";S2"x"S3,"sq.m"; " : CROSS SECTIONAL DIMENSIONS OF THE
 INDIVIDUALDIPOLES"
```

```
330 PRINT :PRINT "c. f=";f(1)/10^9;f(2)/10^9;f(3)/10^9;f(4)/10^9;"GHz";" : FREQ. STEPS"
340 LPRINT : LPRINT "c. f=";f(1)/10^9;f(2)/10^9;f(3)/10^9;f(4)/10^9;"GHz";" :FREQ. STEPS"
350 PRINT : PRINT : PRINT " OUTPUT"
360 PRINT " ------"
370 LPRINT : LPRINT : LPRINT " OUTPUT"
380 LPRINT " ------"
390 FOR I=3 TO 60
400 PRINT "-";
410 LPRINT "-";
420 NEXT I
430 PRINT : PRINT " f [GHz]","l[cm]","Sav[cm sq.]","   N"
440 LPRINT : LPRINT " f [GHz]","l[cm]","Sav[cm sq.]","   N"
450 FOR I=3 TO 60
460 PRINT "-";
470 LPRINT "-";
480 NEXT I
490 PRINT : PRINT f(1)/10^9,l(1),Sav(1),N(1)
500 LPRINT : LPRINT f(1)/10^9,l(1),Sav(1),N(1)
510 FOR I=3 TO 60
520 PRINT "-";
530 LPRINT "-";
540 NEXT I
550 PRINT : PRINT f(2)/10^9,l(2),Sav(2),N(2)
560 LPRINT : LPRINT f(2)/10^9,l(2),Sav(2),N(2)
570 FOR I=3 TO 60
580 PRINT "-";
590 LPRINT "-";
600 NEXT I
610 PRINT : PRINT f(3)/10^9,l(3),Sav(3),N(3)
620 LPRINT : LPRINT f(3)/10^9,l(3),Sav(3),N(3)
630 FOR I=3 TO 60
640 PRINT "-";
650 LPRINT "-";
660 NEXT I
670 PRINT : PRINT f(4)/10^9,l(4),Sav(4),N(4)
```

```
680 LPRINT : LPRINT f(4)/10^9,1(4),Sev(4),N(4)
690  FOR I=3 TO 60
700  PRINT "-";
710  LPRINT "-";
720  NEXT I
730  PRINT : PRINT : PRINT "TABLE CONTINUE :"
740  LPRINT : LPRINT : LPRINT "TABLE CONTINUE :"
750  PRINT : PRINT " V[cu.cm]","  m[grms]","m/S1[grms/sq.m]","    m/S1[lbs/sq.m]"
760 LPRINT : LPRINT " V[cu.cm]","  m[grms]","m/S1[grms/sq.m]";"  m/S1[lbs/sq.m]"
770  FOR I=3 TO 60
780  PRINT "-";
790  LPRINT "-";
800  NEXT I
810  PRINT : PRINT V(1),m(1),m1(1),m2(1)
820  LPRINT : LPRINT V(1),m(1),m1(1),m2(1)
830  FOR I=3 TO 60
840  PRINT "-";
850  LPRINT "-";
860  NEXT I
870  PRINT : PRINT V(2),m(2),m1(2),m2(2)
880  LPRINT : LPRINT V(2),m(2),m1(2),m2(2)
890  FOR I=3 TO 60
900  PRINT "-";
910  LPRINT "-";
920  NEXT I
930  PRINT : PRINT V(3),m(3),m1(3),m2(3)
940  LPRINT : LPRINT  V(3),m(3),m1(3),m2(3)
950  FOR I=3 TO 60
960  PRINT "-";
970  LPRINT "-";
980  NEXT I
990  PRINT : PRINT V(4),m(4),m1(4),m2(4)
1000 LPRINT : LPRINT V(4),m(4),m1(4),m2(4)
1010 PRINT : PRINT " DO YOU WANT TO TRY AGAIN ANOHTE Y/N?"
1020 INPUT A$
```

```
1030  IF LEFT$(A$,1)="Y" OR LEFT$(A$,1)="y" THENLPRINT : LPRINT : GOTO 60
1040  END
```

PROBLEM#6

GIVEN

a. S1= 10 dbsm : AVERAGE VALUE OF THE CLOUD CROSS SECTION

b. S2xS3= .5 x 5 mi.inch : CROSS SECTIONAL DIMENSIONS OF THE INDIVIDUAL DIPOLES

c. f= 1 2 5 10 GHz : FREQ. STEPS

OUTPUT

f [GHz]	l[cm]	Sav[cm sq.]	N
1	30	135	740.741
2	15	33.75	2962.96
5	6	5.4	18518.5
10	3	1.35	74074.1

TABLE CONTINUE:

V[cu.cm]	m[grms]	m/S1[grms/sq.m]	m/S1[lbs/sq.m]
.358422	.967739	.0967739	.00021269
.716844	1.93548	.193548	.00042538
1.79211	4.8387	.48387	.00106345
3.58422	9.67739	.967739	.0021269

```
10   PRINT : PRINT TAB(30); " PROBLEM #7 "
20   PRINT TAB(30); " ---------"
30   GOSUB 100  : GOSUB 1080
40   GOSUB 1390 : GOSUB 1840
50   PRINT : PRINT " DO YOU WANT TO TRY AGAIN FOR DIFFERENT OR THE SAME DATA (Y/N)?"
60   INPUT D$
70   IF LEFT$(D$,1)="Y" OR LEFT$(D$,1)="y" THEN 30
80   END
90   '**********************************
100  '          INPUTS THE DATA
110  '**********************************
120  PRINT : PRINT " ENTER THE PEAK POWER Pp IN MW"
130  INPUT Pp : PRINT : PRINT " 1. Pp=";Pp;"MW"
140  PRINT : PRINT " ENTER THE PULSE WIDTH T IN micsec."
150  INPUT T : PRINT : PRINT " 2. T=";T;"micsec."
160  PRINT : PRINT " ENTER THE P.R.F fp IN Hz"
170  INPUT fp : PRINT : PRINT " 3. fp=";fp;"Hz"
180  PRINT : PRINT " ENTER THE ANTENNA GAIN Ga IN db"
190  INPUT Ga : PRINT : PRINT " 4. Ga=";Ga;"db"
200  PRINT : PRINT " ENTER THE OPERATING FREQ. f0 IN GHz"
210  INPUT f0 : PRINT : PRINT " 5. f0=";f0;"GHz"
220  PRINT : PRINT " ENTER THE RECEIVER NOISE BANDWIDTH Bn IN MHz"
230  INPUT Bn : PRINT : PRINT " 6. Bn=";Bn;"MHz"
240  PRINT : PRINT " ENTER THE ANTENNA SCAN RATE Wm IN RPM"
250  INPUT Wm : PRINT : PRINT " 7. Wm=";Wm;"RPM"
260  PRINT : PRINT " ENTER THE AZIMUTH BEAMWIDTH A.B IN Deg."
270  INPUT A.B : PRINT : PRINT " 8. A.B=";A.B;"Deg."
280  PRINT : PRINT " ENTER THE RECEIVER NOISE FIGURE F IN db"
290  INPUT F : PRINT : PRINT " 9. F=";F;"db"
300  PRINT : PRINT " ENTER THE ANTENNA NOISE TEMPERATURE Ta IN KELVIN"
310  INPUT Ta : PRINT : PRINT " 10. Ta=";Ta;"KELVIN"
320  PRINT : PRINT " ENTER THE PLUMBING LOSSES Lp IN db"
330  INPUT Lp : PRINT : PRINT " 11. Lp=";Lp;"db"
340  PRINT : PRINT " ENTER THE FALSE ALARM PROBABILITY Pfa"
350  INPUT Pfa : PRINT : PRINT " 12. Pfa=";CSNG(Pfa)
```

```
360  PRINT : PRINT "NOW GO TO PART a AND INPUT THE DATA"
370  PRINT : PRINT " ENTER THE CROSS SECTION OF THE NON-FLUCTUATING TARGET S IN dbsm"
380  INPUT S : PRINT : PRINT " 13. S=";S;"dbsm"
390  PRINT : PRINT " ENTER THE PROBABILITY OF DETECTION Pd"
400  INPUT Pd : PRINT : PRINT " 14. Pd=";Pd
410  PRINT : PRINT " GO TO PART b AND INPUT THE DATA"
420  PRINT : PRINT "ENTER THE CROSS SECTION OF THE TARGET AIRCRAFT S1 IN dbsm"
430  INPUT S1 : PRINT : PRINT " 15. S1=";S1;"dbsm"
440  PRINT : PRINT " ENTER THE CROSS SECTION OF THE CHAFF CLOUD S2 IN sq.m"
450  INPUT S2 : PRINT : PRINT " 16. S2=";S2;"sq.m"
460  PRINT : PRINT " ENTER THE RADAR-TARGET DISTANCE R IN KM"
470  INPUT R : PRINT : PRINT " 17. R=";R;"KM"
480  PRINT : PRINT " ENTER THE RADIAL VELOCITY OF THE TARGET Ut IN KNOTS"
490  INPUT Ut : PRINT : PRINT " 18. Ut=";Ut;"KNOTS"
500  PRINT : PRINT " IS THE INPUT DATA CORRECT Y/N?"
510  INPUT A$
520  IF LEFT$(A$,1)="Y" OR LEFT$(A$,1)="y" THEN 1060
530  PRINT : PRINT " WHAT OF THE FOLLOWING DO YOU WANT TO CHANGE?"
540  PRINT : PRINT " 1. THE PEAK POWER?"," 2. THE PULSE WIDTH?"
550  PRINT : PRINT " 3. THE PRF?"," 4. THE ANTENNA GAIN?"
560  PRINT : PRINT " 5. THE OPERATING FREQ.?"," 6. RECEIVER'S NOISE BANDWIDTH?"
570  PRINT : PRINT " 7. THE ANTENNA SCAN RATE?"," 8. THE AZIMUTH BANDWIDTH?"
580  PRINT : PRINT " 9. THE RECEIVER'S NOISE FIGURE?"," 10. THE ANTENNA NOISE
 TEMPERATURE?"
590  PRINT : PRINT " 11. THE PLUMBING LOSSES?"," 12. THE FALSE ALARM PROBABILITY?"
600  PRINT : PRINT " 13. THE CROSS SECTION OF THE TARGET IN PART a?"," 14. THE
 PROBABILITY OF DETECTION OF PART a?"
610  PRINT : PRINT " 15. THE AIRCRAFT'S CROSS SECTION IN PART b?"," 16. THE CHAFF'S CROSS
 SECTION OF PART b?"
620  PRINT : PRINT " 17. THE RANGE OF THE TARGET?"," 18. THE RADIAL VELOCITY OF THE
 AIRCRAFT?"
630  INPUT C$
640  IF C$="1"  THEN PRINT : PRINT " ENTER THE PEAK POWER Pp IN MW"
650  IF C$="1"  THEN INPUT Pp : PRINT : PRINT " 1. Pp=";Pp;"MW" : GOTO 1000
660  IF C$="2"  THEN PRINT : PRINT " ENTER THE PULSE WIDTH T IN micsec."
```

```
670   IF C$="2"   THEN INPUT T : PRINT : PRINT " 2. T=";T;"micsec." : GOTO 1000
680   IF C$="3"   THEN PRINT : PRINT " ENTER THE P.R.F fp IN Hz"
690   IF C$="3"   THEN INPUT fp : PRINT : PRINT " 3. fp=";fp;"Hz" : GOTO 1000
700   IF C$="4"   THEN PRINT . PRINT " ENTER THE ANTENNA GAIN Ga IN db"
710   IF C$="4"   THEN INPUT Ga : PRINT : PRINT " 4. Ga=";Ga;"db" : GOTO 1000
720   IF C$="5"   THEN PRINT : PRINT " ENTER THE OPERATING FREQ. fO IN GHz"
730   IF C$="5"   THEN INPUT fO : PRINT : PRINT " 5. fO=";fO;"GHz" : GOTO 1000
740   IF C$="6"   THEN PRINT : PRINT " ENTER THE RECEIVER NOISE BANDWIDTH Bn IN MHz"
750   IF C$="6"   THEN INPUT Bn : PRINT : PRINT " 6. Bn=";Bn;"MHz" : GOTO 1000
760   IF C$="7"   THEN PRINT : PRINT " ENTER THE ANTENNA SCAN RATE Wm IN RPM"
770   IF C$="7"   THEN INPUT Wm : PRINT : PRINT " 7. Wm=";Wm;"RPM" : GOTO 1000
780   IF C$="8"   THEN PRINT : PRINT " ENTER THE AZIMUTH BEAMWIDTH A.B IN Deg."
790   IF C$="8"   THEN INPUT A.B : PRINT : PRINT " 8. A.B=";A.B;"Deg." : GOTO 1000
800   IF C$="9"   THEN PRINT : PRINT " ENTER THE RECEIVER NOISE FIGURE F IN db"
810   IF C$="9"   THEN INPUT F : PRINT : PRINT " 9. F=";F;"db" : GOTO 1000
820   IF C$="10"   THEN PRINT : PRINT " ENTER THE ANTENNA NOISE TEMPERATURE Ta IN
 KELVIN"
830   IF C$="10"   THEN INPUT Ta : PRINT : PRINT " 10. Ta=";Ta;"KELVIN" : GOTO 1000
840   IF C$="11"   THEN PRINT : PRINT " ENTER THE PLUMBING LOSSES Lp IN db"
850   IF C$="11"   THEN INPUT Lp : PRINT : PRINT " 11. Lp=";Lp;"db" : GOTO 1000
860   IF C$="12"   THEN PRINT : PRINT " ENTER THE FALSE ALARM PROBABILITY Pfa"
870   IF C$="12"   THEN INPUT Pfa : PRINT : PRINT " 12. Pfa=";CSNG(Pfa) : GOTO 1000
880   IF C$="13"   THEN PRINT : PRINT " ENTER THE CROSS SECTION OF THE NON-FLUCTUATING
 TARGET S IN dbsm"
890   IF C$="13"   THEN INPUT S : PRINT : PRINT " 13. S=";S;"dbsm" : GOTO 1000
900   IF C$="14"   THEN PRINT : PRINT " ENTER THE PROBABILITY OF DETECTION Pd"
910   IF C$="14"   THEN INPUT Pd : PRINT : PRINT " 14. Pd=";Pd : GOTO 1000
920   IF C$="15"   THEN PRINT : PRINT " ENTER THE CROSS SECTION OF THE TARGET AIRCRAFT
 S1 IN dbsm"
930   IF C$="15"   THEN INPUT S1 : PRINT : PRINT " 15. S1=";S1;"dbsm" : GOTO 1000
940   IF C$="16"   THEN PRINT : PRINT " ENTER THE CROSS SECTION OF THE CHAFF CLOUD S2 IN
 sq.m"
950   IF C$="16"   THEN INPUT S2 : PRINT : PRINT " 16. S2=",S2;"sq.m" GOTO 1000
960   IF C$="17"   THEN PRINT : PRINT " ENTER THE RADAR-TARGET DISTANCE R IN KM"
970   IF C$="17"   THEN INPUT R : PRINT : PRINT " 17. R=";R;"KM" GOTO 1000
```

```
980  IF C$="18"  THEN PRINT : PRINT " ENTER THE RADIAL VELOCITY OF THE TARGET Ut IN
 KNOTS"
990  IF C$="18"  THEN INPUT Ut : PRINT : PRINT " 18. Ut=";Ut;"KNOTS" : GOTO 1000
1000 PRINT : PRINT " IS EVERYTHING O.K NOW?"
1010 INPUT B$
1020 IF LEFT$(B$,1)="Y" OR LEFT$(B$,1)="y" THEN GOTO 1060
1030 PRINT : PRINT " WHAT DO YOU WANT TO CHANGE AGAIN?"
1040 PRINT : PRINT "HIT ANY KEY IN YOUR KEYBOARD AND EVERYTHING WILL WORK FOR YOU
 MALAKA"
1050 INPUT F$   : GOTO 540
1060 RETURN
1070'*********************************
1080 '     PRINTS THE INPUT DATA
1090'*********************************
1110 LPRINT : LPRINT TAB(30); " PROBLEM #7"
1120 LPRINT TAB(30); " ---------"
1130 LPRINT : LPRINT : LPRINT  " G I V E N"
1140 LPRINT " ---------"
1150 LPRINT : LPRINT " 1. Pp=";Pp;"MW" , "               : PEAK POWER"
1160 LPRINT : LPRINT " 2. T=";T;"micsec." , "   : PULSE WIDTH"
1170 LPRINT : LPRINT " 3. fp=";fp;"Hz" , "    : PRF"
1180 LPRINT : LPRINT " 4. Ga=";Ga;"db" , "               : ANTENNA GAIN"
1190 LPRINT : LPRINT " 5. f0=";f0;"GHz" , "               : OPERATING FREQ."
1200 LPRINT : LPRINT " 6. Bn=";Bn;"MHz" , "    : RECEIVER NOISE BANDWIDTH"
1210 LPRINT : LPRINT " 7. Wm=";Wm;"RPM" , "     : ANTENNA SCAN RATE"
1220 LPRINT : LPRINT " 8. A.B=";A.B;"Deg." , "    : AZIMUTH BEAMWIDTH"
1230 LPRINT : LPRINT " 9. F=";F;"db" , "             : RECEIVER'S NOISE FIGURE"
1240 LPRINT : LPRINT " 10. Ta=";Ta;"KELVIN" , "    : ANTENNA NOISE TEMPERATURE"
1250 LPRINT : LPRINT " 11. Lp=";Lp;"db" , "               : PLUMBING LOSSES"
1260 LPRINT : LPRINT " 12.Pfa=";CSNG(Pfa) , "   : FALSE ALARM PROBABILITY"
1270 LPRINT : LPRINT " GIVEN DATA FOR PART a:"
1280 LPRINT " ----------------------"
1290 LPRINT : LPRINT " 1. S=";S;"dbsm" , "               : TARGET'S CROSS SECTION"
1300 LPRINT : LPRINT " 2. Pd=";Pd , "               : PROBABILITY OF DETECTION"
1310 LPRINT : LPRINT " GIVEN DATA FOR PART b:"
```

```
1320 LPRINT "--------------------"
1330 LPRINT : LPRINT " 1. S1=";S1;"dbsm" , "    : AIRCRAFT'S CROSS SECTION"
1340 LPRINT : LPRINT " 2. S2=";S2;"sq.m" , "    : CHAFF'S CROSS SECTION"
1350 LPRINT : LPRINT " 3. R=";R;"KM" , "              : RADAR-TARGET DISTANCE"
1360 LPRINT : LPRINT " 4. Ut=";Ut;"knots" , "    : RADIAL VELOCITY OF THE AIRCRAFT"
1370 RETURN
1380'****************************************
1390 ' CALCULATION & PRINTOUT FOR PART a:
1400'****************************************
1410 LET PI=3.14159 : C=3*10^8        'm/s
1420 LET K=1.38*10^-23      'BOLTZMAN'S CONST. j/deg.
1430 LET T0=290             'KELVIN
1440 LET f0=f0*10^9 : 1=C/f0
1450 LET Pp=Pp*10^6
1460 LET Ga1=Ga/10: Ga2=CINT(10^Ga1)
1470 LET Ae=CSNG(1^2*Ga2/(4*PI))          'effective area
1480 LET Lp1=Lp/10: Lp2=CSNG(10^Lp1)
1490 LET Sa=S/10 : Sb=10^Sa
1500 LET F1=F/10 : F2=10^F1
1510 LET Te=CINT((F2-1)*T0)
1520 LET Bn=Bn*10^6
1530 PRINT : PRINT " NOW FROM Fig. 2.7 (SKOLNIK Pg. 28) YOU CAN FIND THE (S/N)1 SINCE YOU
NOW:"
1540 PRINT : PRINT "a. Pd=";Pd
1550 PRINT : PRINT "b.Pfa=";CSNG(Pfa)
1560 PRINT : PRINT "ENTER THE (S/N)1,SN IN db"
1570 INPUT SN
1580 LET SN1=SN/10 : SN2=CINT(10^SN1)
1590 LET n=fp*A.B/(6*Wm)
1600 PRINT : PRINT " FROM Fig. 2.8(a) (SKOLNIK Pg. 31) YOU CAN FIND THE INTEGR. IMR. FACTOR
SINCE THE PROGRAM CALCULATED FOR YOY:"
1610 PRINT : PRINT "a. n=";n
1620 PRINT : PRINT "b. Pd=";Pd
1630 PRINT : PRINT "c. nf=";CSNG(1/Pfa)
1640 PRINT : PRINT " ENTER THE INTEGR. IMR. FACTOR li(n), I:I"
```

```
1650 INPUT I11
1660 LET I1=CSNG(10*.4342945#*LOG(I11))
1670 LET Rmax=(Pp*Ga2*Ae*Sb*I11/((4*PI)^2*K*(Ta+Te)*Bn*SN2*Lp2))^(1/4)
1680 PRINT : PRINT : PRINT " PART a:"
1690 PRINT "-------"
1700 LPRINT : LPRINT : LPRINT " PART a:"
1710 LPRINT "-------"
1720 PRINT : PRINT " 1. n=";n;" : #OF HITS INTEGRATED"
1730 PRINT : PRINT "2. (S/N)1=";SN;"db";" :THE SIGNAL-TO-NOISE RATIO "
1740 PRINT : PRINT " 3. I1(n)=";I11;" : THE INTEGR. IMPR. FACTOR"
1750 PRINT : PRINT " 4. nf=";CSNG(1/Pfa);" : FALSE ALARM NUMBER"
1760 PRINT : PRINT " 5.
 Rmax=(Pp*Ga*Ae*S*I1(n)/((4*PI)^2*K*(Ta+Te)*Bn*(S/N)1*Lp))*(1/4)=";CSNG(Rmax/1000)
 ";" : MAX. RANGE"
1770 LPRINT : LPRINT " 1. n=";n;" : #OF HITS INTEGRATED"
1780 LPRINT : LPRINT "2. (S/N)1=";SN;"db";" :THE SIGNAL-TO-NOISE RATIO "
1790 LPRINT : LPRINT " 3. I1(n)=";I11;" : THE INTEGR. IMPR. FACTOR"
1800 LPRINT : LPRINT " 4. nf=";CSNG(1/Pfa);" : FALSE ALARM NUMBER"
1810 LPRINT : LPRINT " 5.
 Rmax=(Pp*Ga*Ae*S*I1(n)/((4*PI)^2*K*(Ta+Te)*Bn*(S/N)1*Lp))*(1/4)=";CSNG(Rmax/1000)
 ";" : MAX. RANGE"
1820 RETURN
1830'*****************************************
1840 ' CALCULATION & PRINTOUT OF PART b:
1850'*****************************************
1860 LET fd=1.03*Ut/l
1870 LET H=CSNG(4*(SIN(PI*fd/fp))^2)
1880 LET A=1E+16
1890 LET CA=A*fp^2/(2*PI^2*f0^2)
1900 LET CA=CINT(CA)
1910 LET CA1=CSNG(10*.4342945#*LOG(CA))
1920 LET SCin=S1/S2
1930 LET SC=CINT(10*.4342945#*LOG(SCin))
1940 LET SCout=CINT(SCin*H*CA)
1950 LET SCout=CINT(10*.4342945#*LOG(SCout))
```

```
1960 PRINT : PRINT : PRINT " PART b:"
1970 PRINT "-------"
1980 LPRINT : LPRINT : LPRINT " PART b:"
1990 LPRINT "-------"
2000 PRINT : PRINT " I.(S/C)out=";SCout;"db"; ": SIGNAL-TO-CLUTTER RATIO AT THE OUTPUT
 OF THE DELAY LINE CANCELLER"
2010 LPRINT : LPRINT " I.(S/C)out=";SCout;"db"; ": SIGNAL-TO-CLUTTER RATIO AT THE OUTPUT
 OF THE DELAY LINE CANCELLER"
2020 RETURN
```

PROBLEM#7

GIVEN

1. Pp= 1 MW	: PEAK POWER
2. T= 1.4 micsec.	: PULSE WIDTH
3. fp= 800 Hz	: PRF
4. Ga= 26 db	: ANTENNA GAIN
5. f0= 1 GHz	: OPERATING FREQ.
6. Bn= 1.5 MHz	: RECEIVER NOISE BANDWIDTH
7. Wm= 10 RPM	: ANTENNA SCAN RATE
8. A.B= 3.9 Deg.	: AZIMUTH BEAMWIDTH
9. F= 9 db	: RECEIVER'S NOISE FIGURE
10. Ta= 100 KELVIN	: ANTENNA NOISE TEMPERATURE
11. Lp= 2 db	: PLUMBING LOSSES
12. Pfa= 1E-12	: FALSE ALARM PROBABILITY

GIVEN DATA FOR PART a:

1. S= 0 dbsm	: TARGET'S CROSS SECTION
2. Pd= .9	: PROBABILITY OF DETECTION

GIVEN DATA FOR PART b:

1. S1= 10 dbsm	: AIRCRAFT'S CROSS SECTION
2. S2= 500 sq.m	: CHAFF'S CROSS SECTION
3. R= 30 KM	: RADAR-TARGET DISTANCE
4. Ut= 300 knots	: RADIAL VELOCITY OF THE AIRCRAFT

PART a:

1. n= 52	: #OF HITS INTEGRATED
2. (S/N)1= 15.8 db	: THE SIGNAL-TO-NOISE RATIO
3. Ii(n)= 23.5	: THE INTEGR. IMPR. FACTOR
4. nf= 1E+12	: FALSE ALARM NUMBER

5.Rmax=(Pp*Ga*Ae*S*Ii(n)/((4*PI)^2*K*(Ta+Te)*Bn*(S/N)1*Lp))^(1/4)=89.4533Km MAX RANGE

PART b:

: $(S/C)_{out}$ = 12 db : SIGNAL-TO-CLUTTER RATIO AT THE OUTPUT OF THE DELAY LINE CANCELLER

```
10   PRINT : PRINT TAB(30); " PROBLEM #8"
20   PRINT TAB(30); " ----------"
30   GOSUB 100 : GOSUB 1020 : GOSUB 1250
40   GOSUB 1410 : GOSUB 1680 : GOSUB 1890
50   PRINT : PRINT " DO YOU WANT TO TRY AGAIN FOR DIFFERENT OR THE SAME DATA [illegible]
60    INPUT D$
70   IF LEFT$(D$,1) ="Y" OR LEFT$(D$,1)="y"   THEN 30
80    END
90   '********************************
100  '          INPUTS THE DATA
110  '********************************
120  PRINT : PRINT " ENTER THE RANGE OF THE OPERATING FREQ. f10,f20 IN GHz"
130  INPUT f10,f20 : PRINT : PRINT " 1. f10=";f10,"f20=";f20;"GHz"
140  PRINT : PRINT " ENTER THE PEAK POWER Pp IN KW"
150   INPUT Pp : PRINT : PRINT " 2. Pp=";Pp;"KW"
160  PRINT : PRINT " ENTER THE PRF fp IN Hz"
170   INPUT fp : PRINT : PRINT " 3. fp=";fp;"Hz"
180  PRINT : PRINT " ENTER THE PULSEWIDTH T IN nsec."
190  INPUT T : PRINT : PRINT " 4. T=";T;"nsec."
200  PRINT : PRINT " ENTER THE ANTENNA GAIN Ga IN db"
210   INPUT Ga : PRINT : PRINT " 5. Ga=";Ga;"db"
220  PRINT : PRINT " ENTER THE AZIMUTH BEAMWIDTH A.B IN Deg."
230  INPUT A.B : PRINT : PRINT " 6. A.B=";A.B;"Deg."
240  PRINT : PRINT " ENTER THE ANTENNA SCAN RATE Wm IN RPM"
250  INPUT Wm : PRINT : PRINT " 7. Wm=";Wm;"RPM"
260  PRINT : PRINT " ENTER THE PLUMBING LOSSES Lp IN db"
270   INPUT Lp : PRINT : PRINT " 8. Lp=";Lp;"db"
280   PRINT : PRINT " ENTER THE Rx NOISE FIGURE Rx IN db"
290   INPUT Rx : PRINT : PRINT " 9. Rx=";Rx;"db"
300  PRINT : PRINT " ENTER THE AIRCRAFT'S ALTITUDE Ha IN ft"
310   INPUT Ha : PRINT : PRINT " 10. Ha=";Ha;"ft"
320  PRINT : PRINT " ENTER THE RANGE TO SUBMARINE Rs IN Kyards"
330  INPUT Rs : PRINT : PRINT " 11. Rs=";Rs;"Kyards"
340  PRINT : PRINT " ENTER THE PERISCOPE RCS IN sq. m"
350  INPUT RCS : PRINT : PRINT " 12. RCS=";RCS;"sq.m"
```

```
360  PRINT : PRINT " NOW GO TO PART (a) AND INPUT : "
370  PRINT : PRINT " ENTER THE AVERAGE DURATION OF THE SEA CLUTTER SPIKES t1fa IN sec."
380  INPUT t1fa : PRINT : PRINT " 13. t1fa=";t1fa;"sec."
390  PRINT : PRINT " ENTER THE FALSE ALARM TIME Tfa IN sec."
400  INPUT Tfa : PRINT : PRINT " 14. Tfa=";Tfa;"sec."
410  PRINT : PRINT " NOW FROM PART (d) INPUT :"
420  PRINT : PRINT " ENTER THE POST DETECTION INTEGRATION PERIOD Ts IN sec. "
430  INPUT Ts : PRINT : PRINT " 15. Ts=";Ts;"sec."
440  PRINT : PRINT " IS THE INPUT DATA CORRECT Y/N?"
450  INPUT A$
460  IF LEFT$(A$,1)="Y" OR LEFT$(A$,1)="y"   THEN 1000
470  PRINT " WHAT OF THE FOLLOWING DO YOU WANT TO CHANGE?"
480  PRINT : PRINT " 1. THE RANGE OF THE OPERATING FREQ.?"
490  PRINT : PRINT " 2. THE PEAK POWER?"
500  PRINT : PRINT " 3. THE P.R.F?"
510  PRINT : PRINT " 4. THE PULSEWIDTH?"
520  PRINT : PRINT " 5. THE ANTENNA GAIN?"
530  PRINT : PRINT " 6. THE AZIMUTH BEAMWIDTH?"
540  PRINT : PRINT " 7. THE ANTENNA SCAN RATE?"
550  PRINT : PRINT " 8. THE PLUMBING LOSSES?"
560  PRINT : PRINT " 9. THE Rx NOISE FIGURE?"
570  PRINT : PRINT " 10. THE AIRCRAFT'S ALTITUDE?"
580  PRINT : PRINT " 11. THE RANGE TO SUBMARINE?"
590  PRINT : PRINT " 12. THE PERISCOPE RCS?"
600  PRINT : PRINT " 13. THE AVERAGE DURATION OF THE SPIKES?"
610  PRINT : PRINT " 14. THE FALSE ALARM TIME?"
620  PRINT : PRINT " 15. THE POST DETECTION INTEGRATION PERIOD?"
630  INPUT C$
640  IF C$="1"   THEN PRINT : PRINT " ENTER THE RANGE OF THE OPERATING FREQ. f10,f20 IN
 GHz"
650  IF C$="1"   THEN INPUT f10,f20 : PRINT : PRINT " 1. f10=";f10,"f20=";f20;"GHz" : GOTO 940
660  IF C$="2"   THEN PRINT : PRINT " ENTER THE PEAK POWER Pp IN KW"
670  IF C$="2"   THEN INPUT Pp : PRINT : PRINT " 2. Pp=";Pp;"KW" : GOTO 940
680  IF C$="3"   THEN PRINT : PRINT " ENTER THE PRF fp IN Hz"
690  IF C$="3"   THEN INPUT fp : PRINT : PRINT " 3. fp=";fp;"Hz" : GOTO 940
```

```
700  IF C$="4"  THEN PRINT : PRINT " ENTER THE PULSEWIDTH T IN nsec."
710  IF C$="4"  THEN INPUT T : PRINT : PRINT " 4. T=";T;"nsec." : GOTO 940
720  IF C$="5"  THEN PRINT : PRINT " ENTER THE ANTENNA GAIN Ga IN db"
730  IF C$="5"  THEN INPUT Ga : PRINT : PRINT " 5. Ga=";Ga;"db" : GOTO 940
740  IF C$="6"  THEN PRINT : PRINT " ENTER THE AZIMUTH BEAMWIDTH A.B IN Deg."
750  IF C$="6"  THEN INPUT A.B : PRINT : PRINT " 6. A.B=";A.B;"Deg." : GOTO 940
760  IF C$="7"  THEN PRINT : PRINT " ENTER THE ANTENNA SCAN RATE Wm IN RPM"
770  IF C$="7"  THEN INPUT Wm : PRINT : PRINT " 7. Wm=";Wm;"RPM" : GOTO 940
780  IF C$="8"  THEN PRINT : PRINT " ENTER THE PLUMBING LOSSES Lp IN db"
790  IF C$="8"  THEN INPUT Lp : PRINT : PRINT " 8. Lp=";Lp;"db" : GOTO 940
800  IF C$="9"  THEN PRINT : PRINT " ENTER THE Rx NOISE FIGURE Rx IN db"
810  IF C$="9"  THEN INPUT Rx : PRINT : PRINT " 9. Rx=";Rx;"db" : GOTO 940
820  IF C$="10"  THEN PRINT : PRINT " ENTER THE AIRCRAFT'S ALTITUDE Ha IN ft"
830  IF C$="10"  THEN INPUT Ha : PRINT : PRINT " 10. Ha=";Ha;"ft" : GOTO 940
840  IF C$="11"  THEN PRINT : PRINT " ENTER THE RANGE TO SUBMARINE Rs IN Kyards"
850  IF C$="11"  THEN INPUT Rs : PRINT : PRINT " 11. Rs=";Rs;"Kyards" : GOTO 940
860  IF C$="12"  THEN PRINT : PRINT " ENTER THE PERISCOPE RCS IN sq. m"
870  IF C$="12"  THEN INPUT RCS : PRINT : PRINT " 12. RCS=";RCS;"sq.m" : GOTO 940
880  IF C$="13"  THEN PRINT : PRINT " ENTER THE AVERAGE DURATION OF THE SEA CLUTTER
 SPIKES t1fa IN sec."
890  IF C$="13"  THEN INPUT t1fa : PRINT : PRINT " 13. t1fa=";t1fa;"sec." : GOTO 940
900  IF C$="14"  THEN PRINT : PRINT " ENTER THE FALSE ALARM TIME Tfa IN sec."
910  IF C$="14"  THEN INPUT Tfa : PRINT : PRINT " 14. Tfa=";Tfa;"sec." : GOTO 940
920  IF C$="15"  THEN PRINT : PRINT " ENTER THE POST DETECTION INTEGRATION PERIOD Ts IN
 sec."
930  IF C$="15"  THEN INPUT Ts : PRINT : PRINT " 15. Ts=";Ts;"sec." : GOTO 940
940  PRINT : PRINT " IS EVERYTHING O.K NOW?"
950  INPUT B$
960  IF LEFT$(B$,1)="Y" OR LEFT$(B$,1)="y"  THEN 1000
970  PRINT : PRINT " WHAT DO YOU WANT TO CHANGE AGAIN?"
980  PRINT : PRINT " HIT ANY KEY IN YOUR KEYBOARD AND EVERYTHING WILL WORK FOR YOU
 MALAKA"
990  INPUT F$  : GOTO 480
1000 RETURN
1010 '*********************************
```

```
1020 '      PRINTS THE INPUT DATA
1030'**********************************
1040 LPRINT : LPRINT TAB(30); " PROBLEM #8"
1050 LPRINT TAB(30); " -----------"
1060 LPRINT : LPRINT " G I V E N"
1070 LPRINT "----------"
1080 LPRINT : LPRINT " 1. f10=";f10,"f20=";f20;"GHz" SPC(1); " : RANGE OF THE OPERATING
FREQ."
1090 LPRINT : LPRINT " 2. Pp=";Pp;"KW" SPC(10); " : PEAK POWER"
1100 LPRINT : LPRINT " 3. fp=";fp;"Hz" SPC(9); " : P.R.F"
1110 LPRINT : LPRINT " 4. T=";T;"nsec." SPC(8); " : PULSEWIDTH"
1120 LPRINT : LPRINT " 5. Ga=";Ga;"db" SPC(11); " : ANTENNA GAIN"
1130 LPRINT : LPRINT " 6. A.B=";A.B;"Deg." SPC(6); " : AZIMUTH BEAMWIDTH"
1140 LPRINT : LPRINT " 7. Wm=";Wm;"RPM" SPC(9); " : ANTENNA SCAN RATE"
1150 LPRINT : LPRINT " 8. Lp=";Lp;"db" SPC(12); " : PLUMBING LOSSES"
1160 LPRINT : LPRINT " 9. Rx=";Rx;"db" SPC(10); " : Rx NOISE FIGURE"
1170 LPRINT : LPRINT " 10. Ha=";Ha;"ft" SPC(8); " : AIRCRAFT'S ALTITUDE"
1180 LPRINT : LPRINT " 11. Rs=";Rs;"Kyards" SPC(6); " : RANGE TO SUBMARINE"
1190 LPRINT : LPRINT " 12. RCS=";RCS;"sq.m" SPC(8); " : PERISCOP'S RCS"
1200 LPRINT : LPRINT " 13. t1fa=";t1fa;"sec." SPC(7); " : AVERAGE DURATION OF THE SEA
CLUTTERSPIKES"
1210 LPRINT : LPRINT " 14. Tfa=";Tfa;"sec." SPC(6); " : FALSE ALARM TIME"
1220 LPRINT : LPRINT " 15. Ts=";Ts;"sec." SPC(9); " : POST DETECTION INTEGRATION PERIOD"
1230 RETURN
1240'*****************************************
1250 ' CALCULATION & PRINTOUT FOR PART (a)
1260'*****************************************
1270 PRINT : PRINT : PRINT " PART (a)"
1280 PRINT "---------"
1290 LPRINT : LPRINT : LPRINT " PART (a)"
1300 LPRINT "---------"
1310 LET Pfa=t1fa/Tfa
1320 PRINT : PRINT "FROM Fig. 13.5 (SKOLNIK Pg. 479) YOU CAN FIND THE THRESHOLD LEVEL
""TRSH"" SINCE YOU KNOW:"
1330 PRINT : PRINT " a. Pfa=";Pfa;" : PROBABILITY OF FALSE ALARM"
```

```
1340  INPUT " b. THE SEA STATE IS", K$
1350  PRINT : PRINT " ENTER THE THRESHOLD LEVEL REQUIRED TO ACHIEVE Pfa=";Pfa
1360  INPUT TRSH
1370  LPRINT : LPRINT " 1(a). Pfa=";Pfa; " : FALSE ALARM PROBABILITY"
1380  LPRINT : LPRINT " 2(a). THRESHOLD=";TRSH;"db"; " : LEVEL THAT THE THRESH. MUST BE SET
 ABOVE THE MEDIAN CLUTTER TO ACHIEVE Pfa=";Pfa
1390  RETURN
1400'****************************************
1410  ' CALCULATION & PRINTOUT FOR PART (b)
1420'****************************************
1430  PRINT : PRINT : PRINT " PART (b)"
1440  PRINT "--------"
1450  LPRINT : LPRINT : LPRINT " PART (b)"
1460  LPRINT "--------"
1470  LET C=3*10^8 :  PI=3.14159 :  f20=f20*10^9
1480  LET l=C/f20
1490  LET Ga1=Ga/10: Ga2=CINT(10^Ga1)
1500  LET Lp1=Lp/10 : Lp2=10^Lp1
1510  LET Pp=Pp*10^3
1520  LET Ae=CSNG(Ga2*l^2/(4*PI))
1530  LET Rs=Rs*10^3*.914
1540 LET sec=CINT(1/COS(A.B*PI/180))
1550  LET T=T*10^-9
1560  PRINT : PRINT " FROM FIG 13.3 (SKOLNIK Pg. 475) YOU CAN FIND THE CROSS SECTION SINCE
 YOU KNOW :"
1570  PRINT : PRINT " THE GRAZING ANGLE=";sec;" & THE POLARIZATION"
1580  PRINT : PRINT " ENTER THE CROSS SECTION So IN db"
1590  INPUT So : So1=So/10 : So2=10^So1
1600 LET S=CSNG(Pp*Ga2*RCS*Ae/((4*PI)^2*Rs^4*Lp2))
1610 LET C1=CSNG(Pp*Ga2*Ae*So2*(A.B*PI/180)*(C*T/2)*sec/((4*PI)^2*Rs^3*(Lp2/2)))
1620  LET SC=S/C1
1630 LET SC=CSNG(10*.4342945**LOG(SC))
1640  PRINT : PRINT " 1(b). (S/C)m=";SC;"db"; " : SINGLE PULSE SIGNAL-TO-CLUTTER RATIO AT
 THE RADAR RECEIVER INPUT"
1650  LPRINT : LPRINT " 1(b). (S/C)m=";SC;"db"; " : SINGLE PULSE SIGNAL-TO-CLUTTER RATIO AT
```

```
THE RADARRECEIVER INPUT"
1660 RETURN
1670'*****************************************
1680 ' CALCULATION & PRINTOUT FOR PART (c)
1690'*****************************************
1700 PRINT : PRINT : PRINT " PART (c)"
1710 PRINT "--------"
1720 LPRINT : LPRINT : LPRINT " PART (c)"
1730 LPRINT "--------"
1740 PRINT : PRINT " FROM TABLE 11.1 (SKOLNIK Pg.426) SINCE YOU KNOW THE WEIGHTING
FILTER YOU USE, YOU CAN FIND :"
1750 INPUT "a. THE PEAK SIDELOBE SLL IN db",SLL
1760 INPUT "b. THE LOSS IN db",LOSS
1770 INPUT "c. MAINLOBE WIDTH (relative) M.W",M.W
1780 LET f10=f10*10^9
1790 LET W=f20-f10
1800 LET Tc=T/(T*W)*M.W
1810 LET A=CSNG(10*.4342945#*LOG(2*T*W)-LOSS)
1820 LET SC1=SC+A
1830 PRINT : PRINT " 1(c). Tc=";Tc;"sec."; " : 3 db WIDTH OF THE COMPRESSED PULSE"
1840 PRINT : PRINT " 2(c). (S/C)out=";SC1;"db";" : SIGNAL-MEAN CLUTTER POWER"
1850 LPRINT : LPRINT " 1(c). Tc=";Tc;"sec."; " : 3 db WIDTH OF THE COMPRESSED PULSE"
1860 LPRINT : LPRINT " 2(c). (S/C)out=";SC1;"db";" : SIGNAL-MEAN CLUTTER POWER"
1870 RETURN
1880'*****************************************
1890 ' CALCULATION & PRINTOUT FOR PART (d)
1900'*****************************************
1910 PRINT : PRINT : PRINT " PART (d)"
1920 PRINT "--------"
1930 LPRINT : LPRINT : LPRINT " PART (d)"
1940 LPRINT "--------"
1950 LET ns=A.B*fp/(6*Wm)
1960 LET n=ns*(300/60)*Ts
1970 PRINT : PRINT " FROM FIG 2.8(a) (SKOLNIK Pg. 31) YOU CAN FIND THE Ei(n) SINCE YOU KNOW
```

```
1980 PRINT : PRINT " a. #OF HITS=";n
1990 PRINT : PRINT " b. YOU 'RE IN POST DETECTION CASE"
2000 PRINT : PRINT " ENTER THE INTEGRATION IMPR. FACTIOR I1 "
2010 INPUT I1
2020 LET I1=CINT(10*.4342945#*LOG(I1))
2030 LET B=SC1+I1
2040 PRINT : PRINT " 1(d). n=";n; " : #OF HITS"
2050 PRINT : PRINT " 2(d). I1(n)=";I1;"db"; " : INTEGRATION IMPR. FACTOR"
2060 PRINT : PRINT " 3(d). (S/C)=(S/C)out+I1(n)=";B;"db"; " : INTEGR. IMPROVEMENT"
2070 LPRINT : LPRINT " 1(d). n=";n; " : #OF HITS"
2080 LPRINT : LPRINT " 2(d). I1(n)=";I1;"db"; " : INTEGRATION IMPR. FACTOR"
2090 LPRINT : LPRINT " 3(d). (S/C)=(S/C)out+I1(n)=";B;"db"; " : INTEGR. IMPROVEMENT"
2100 RETURN
```

PROBLEM#8

GIVEN

1. f_{10}= 9.5 f_{20}= 10 GHz : RANGE OF THE OPERATING FREQ.
2. Pp= 500 KW : PEAK POWER
3. fp= 1500 Hz : P.R.F
4. T= 500 nsec. : PULSEWIDTH
5. Ga= 35 db : ANTENNA GAIN
6. A.B= 2.4 Deg. : AZIMUTH BEAMWIDTH
7. Wm= 300 RPM : ANTENNA SCAN RATE
8. Lp= 5 db : PLUMBING LOSSES
9. Rx= 7.5 db : Rx NOISE FIGURE
10. Ha= 2000 ft : AIRCRAFT'S ALTITUDE
11. Rs= 16 Kyards : RANGE TO SUBMARINE
12. RCS= 1 sq.m : PERISCOP'S RCS
13. t1fa= 2 sec. : AVERAGE DURATION OF THE SEA CLUTTER SPIKES
14. Tfa= 100 sec. : FALSE ALARM TIME
15. Ts= 5 sec. : POST DETECTION INTEGRATION PERIOD

PART (a)

1(a). Pfa= .02 : FALSE ALARM PROBABILITY

2(a). THRESHOLD= 12.5 db : LEVEL THAT THE THRESH. MUST BE SET ABOVE THE MEDIAN CLUTTER TO ACHIEVE Pfa=.02

PART (b)

1(b). (S/C)m=-17.6325 db : SINGLE PULSE SIGNAL-TO-CLUTTER RATIO AT THE RADAR RECEIVER INPUT

PART (c)

1(c). Tc= .000000003 sec. : 3 db WIDTH OF THE COMPRESSED PULSE

2(c). (S/C)out= 8.0172 db : SIGNAL-MEAN CLUTTER POWER

PART (d)

1(d). n= 50 : #OF HITS

2(d). I1(n)= 14 db : INTEGRATION IMPR. FACTOR

3(d). (S/C)=(S/C)out+I1(n)= 22.0172 db: INTEGR. IMPROVEMENT

```
10   PRINT : PRINT TAB(30); " PROBLEM #9 "
20   PRINT TAB(30); " ---------"
30   GOSUB 90 : GOSUB 890  : GOSUB 1100
40   PRINT : PRINT " DO YOU WANT TO TRY AGAIN FOR DIFFERENT OR THE SAME DATA [illegible]"
50    INPUT D$
60   IF LEFT$(D$,1)="Y" OR LEFT$(D$,1)="y"   THEN 30
70    END
80   '**********************************
90   '            INPUTS THE DATA
100  '**********************************
110  PRINT : PRINT " ENTER THE OPERATING FREQ. f0 IN GHz"
120   INPUT f0 : PRINT : PRINT " 1. f0=";f0;"GHz"
130  PRINT : PRINT " ENTER THE PEAK POWER Pp IN MW"
140   INPUT Pp : PRINT : PRINT " 2. Pp=";Pp;"MW"
150  PRINT : PRINT " ENTER THE ANTENNA GAIN Ga IN db"
160   INPUT Ga : PRINT : PRINT " 3. Ga=";Ga;"db"
170  PRINT : PRINT " ENTER THE AZIMUTH BEAMWIDTH A.B IN Deg."
180  INPUT A.B : PRINT : PRINT " 4. A.B=";A.B;"Deg."
190  PRINT : PRINT " ENTER THE ELEVATION COVERAGE ECmin,ECmax IN Deg."
200  INPUT ECmin,ECmax : PRINT : PRINT " 5. ECmin=";ECmin; " ECmax=";ECmax;" Deg."
210  PRINT : PRINT " ENTER THE ANTENNA SCAN RATE Wm IN RPM"
220  INPUT Wm : PRINT : PRINT " 6. Wm=";Wm;"RPM"
230   PRINT : PRINT " ENTER THE P.R.F fp IN Hz"
240   INPUT fp : PRINT : PRINT " 7. fp=";fp;"Hz"
250  PRINT : PRINT " ENTER THE PULSE WIDTH T IN microsec."
260  INPUT T : PRINT : PRINT " 8. T=";T;"microsec."
270  PRINT : PRINT " ENTER THE RECEIVER NOISE FIGURE F IN db"
280   INPUT F : PRINT : PRINT " 9. F=";F;"db"
290  PRINT : PRINT " ENTER THE AIRCRAFT'S RADAR CROSS SECTION RCS IN dbsm"
300  INPUT RCS : PRINT : PRINT " 10. RCS=";RCS;"dbsm"
310  PRINT : PRINT " ENTER THE RANGE OF THE AIRCRAFT R IN Km"
320   INPUT R : PRINT : PRINT " 11. R=";R;"Km"
330  PRINT : PRINT " ENTER THE CHAFF RMS VELOCITY SPREAD Su IN m/sec."
340  INPUT Su : PRINT : PRINT " 12. Su=";Su;"m/sec."
350  PRINT : PRINT " ENTER THE CLUTTER-TARGET SIGNAL RATIO (S/N)out IN db"
```

```
360  INPUT SNout : PRINT : PRINT " 13. SNout=";SNout;"db"
370  PRINT : PRINT " IS THE INPUT DATA CORRECT Y/N?"
380  INPUT A$
390  IF LEFT$(A$,1)="Y" OR LEFT$(A$,1)="y" THEN 870
400  PRINT " WHAT OF THE FOLLOWING DO YOU WANT TO CHANGE?"
410  PRINT : PRINT " 1. THE OPERATING FREQ.?"
420  PRINT : PRINT " 2. THE PEAK POWER?"
430  PRINT : PRINT " 3. THE ANTENNA GAIN?"
440  PRINT : PRINT " 4. THE AZIMUTH BEAMWIDTH?"
450  PRINT : PRINT " 5. THE RANGE OF THE ELEVATION COVERAGE?"
460  PRINT : PRINT " 6. THE ANTENNA SCAN RATE?"
470  PRINT : PRINT " 7. THE P.R.F?"
480  PRINT : PRINT " 8. THE PULSE WIDTH?"
490  PRINT : PRINT " 9. THE RECEIVER NOISE FIGURE?"
500  PRINT : PRINT " 10. THE AIRCRAFT'S RADAR CROSS SECTION?"
510  PRINT : PRINT " 11. THE RANGE OF THE AIRCRAFT?"
520  PRINT : PRINT " 12. THE CHAFF'S RMS VELOCITY SPREAD?"
530  PRINT : PRINT " 13. THE CLUTTER-TARGET SIGNAL RATIO?"
540  INPUT C$
550  IF C$="1"  THEN PRINT : PRINT " ENTER THE OPERATING FREQ. f0 IN GHz"
560  IF C$="1"  THEN INPUT f0 : PRINT : PRINT " 1. f0=";f0;"GHz" : GOTO 810
570  IF C$="2"  THEN PRINT : PRINT " ENTER THE PEAK POWER Pp IN MW"
580  IF C$="2"  THEN INPUT Pp : PRINT : PRINT " 2. Pp=";Pp;"MW" : GOTO 810
590  IF C$="3"  THEN PRINT : PRINT " ENTER THE ANTENNA GAIN Ga IN db"
600  IF C$="3"  THEN INPUT Ga : PRINT : PRINT " 3. Ga=";Ga;"db" : GOTO 810
610  IF C$="4"  THEN PRINT : PRINT " ENTER THE AZIMUTH BEAMWIDTH A.B IN Deg."
620  IF C$="4"  THEN INPUT A.B : PRINT : PRINT " 4. A.B=";A.B;"Deg." : GOTO 810
630  IF C$="5"  THEN PRINT : PRINT " ENTER THE ELEVATION COVERAGE ECmin,ECmax IN Deg."
640  IF C$="5"  THEN INPUT ECmin,ECmax : PRINT : PRINT " 5. ECmin=";ECmin;"
 ECmax=";ECmax;" Deg." : GOTO 810
650  IF C$="6"  THEN PRINT : PRINT " ENTER THE ANTENNA SCAN RATE Wm IN RPM"
660  IF C$="6"  THEN INPUT Wm : PRINT : PRINT " 6. Wm=";Wm;"RPM" : GOTO 810
670  IF C$="7"  THEN PRINT : PRINT " ENTER THE P.R.F fp IN Hz"
680  IF C$="7"  THEN INPUT fp : PRINT : PRINT " 7. fp=";fp;"Hz" : GOTO 810
690  IF C$="8"  THEN PRINT : PRINT " ENTER THE PULSE WIDTH T IN microsec."
```

```
700   IF C$="8"   THEN INPUT T : PRINT : PRINT " 8. T=";T;"microsec." : GOTO 810
710   IF C$="9"   THEN PRINT : PRINT " ENTER THE RECEIVER NOISE FIGURE F IN db"
720   IF C$="9"   THEN INPUT F : PRINT : PRINT " 9. F=";F;"db" : GOTO 810
730   IF C$="10"   THEN PRINT : PRINT " ENTER THE AIRCRAFT'S RADAR CROSS SECTION RCS IN
 dbsm"
740   IF C$="10"   THEN INPUT RCS : PRINT : PRINT " 10. RCS=";RCS;"dbsm" : GOTO 810
750   IF C$="11"   THEN PRINT : PRINT " ENTER THE RANGE OF THE AIRCRAFT R IN Km"
760   IF C$="11"   THEN INPUT R : PRINT : PRINT " 11. R=";R;"Km" : GOTO 810
770   IF C$="12"   THEN PRINT : PRINT " ENTER THE CHAFF RMS VELOCITY SPREAD Su IN m/sec."
780   IF C$="12"   THEN INPUT Su : PRINT : PRINT " 12. Su=";Su;"m/sec." : GOTO 810
790   IF C$="13"   THEN PRINT : PRINT " ENTER THE CLUTTER-TARGET SIGNAL RATIO (S/N)out IN
 db"
800   IF C$="13"   THEN INPUT SNout : PRINT : PRINT " 13. SNout=";SNout;"db" : GOTO 810
810   PRINT : PRINT " IS EVERYTHING O.K NOW?"
820   INPUT B$
830   IF LEFT$(B$,1)="Y" OR LEFT$(B$,1)="y"   THEN GOTO 870
840   PRINT : PRINT " WHAT DO YOU WANT TO CHANGE AGAIN?"
850   PRINT : PRINT " HIT ANY KEY IN YOUR KEYBOARD AND EVERYTHING WILL WORK FOR YOU
 MALAKA"
860   INPUT F$ : GOTO 410
870   RETURN
880 '*********************************
890 '      PRINTS THE INPUT DATA
900 '*********************************
910   LPRINT : LPRINT TAB(30); " PROBLEM #9"
920   LPRINT TAB(30); " ---------"
930   LPRINT : LPRINT " G I V E N"
940   LPRINT " ---------"
950   LPRINT : LPRINT " 1. f0=";f0;"GHz" SPC(15); " : OPERATING FREQ."
960   LPRINT : LPRINT " 2. Pp=";Pp;"MW" SPC(18); " : PEAK POWER"
970   LPRINT : LPRINT " 3. Ga=";Ga;"db" SPC(17); " : ANTENNA GAIN"
980   LPRINT : LPRINT " 4. A.B=";A.B;"Deg." SPC(13); " : AZIMUTH BEAMWIDTH"
990   LPRINT : LPRINT " 5. ECmin=";ECmin; " ECmax=";ECmax;" Deg."; " : RANGE OF ELEVATION
 COVERAGE"
1000  LPRINT : LPRINT " 6. Wm=";Wm;"RPM" SPC(17); " : ANTENNA SCAN RATE"
```

```
1010 LPRINT : LPRINT " 7. fp=";fp;"Hz" SPC(16); " :P.R.F"
1020 LPRINT : LPRINT "8. T=";T;"microsec." SPC(12); ": PULSE WIDTH"
1030 LPRINT : LPRINT " 9. F=";F;"db" SPC(19); " : RECEIVER NOISE FIGURE"
1040 LPRINT : LPRINT " 10.RCS=";RCS;"dbsm" SPC(13); " : AIRCRAFT'S RADAR CROSS SECTION"
1050 LPRINT : LPRINT " 11. R=";R;"Km" SPC(16); " : RANGE OF THE AIRCRAFT"
1060 LPRINT : LPRINT " 12. Su=";Su;"m/sec." SPC(13); " :CHAFF RMS VELOCITY SPREAD"
1070 LPRINT :LPRINT " 13. SNout=";SNout;"db" SPC(11); " : CLUTTER-TARGET SIGNAL RATIO
(S/N)out"
1080 RETURN
1090'****************************************
1100 ' CALCULATION & PRINTOUT OF THE OUTPUT
1120'****************************************
1130 PRINT : PRINT : PRINT " OUTPUT"
1140 PRINT " ------"
1150 LPRINT : LPRINT : LPRINT " OUTPUT"
1160 LPRINT " ------"
1170 LET C=3*10^8
1180 LET f0=f0*10^9
1190 LET l=C/f0
1200 LET PI=3.14159
1210 LET Imax=CINT(fp^2*l^2/(16*PI^2*Su)*(4))
1220 LET Imax1=CSNG(10*.4342945**LOG(Imax))
1230 PRINT : PRINT "THE BEST IMPROVEMENT THE DELAY LINE CANCELER WILL PROVIDE IS :"
1240 PRINT : PRINT " Imax=";Imax;"numeric";" OR";Imax1;"db"
1250 LPRINT : LPRINT " THE BEST IMPROVEMENT THE DELAY LINE CANCELER WILL PROVIDE IS :"
1260 LPRINT : LPRINT " Imax=";Imax;"numeric";" OR";Imax1;"db"
1270 LET SNin=-SNout-Imax1
1280 LET SNin=SNin/10 : SNin=10^SNin
1290 LET N=CSNG(RCS/(.15*l^2*SNin))
1300 PRINT : PRINT "N=";N;" : DIPOLES IN RESOLUTION CELL"
1310 LPRINT : LPRINT "N=";N;" : DIPOLES IN RESOLUTION CELL"
1320 RETURN
```

PROBLEM#9

GIVEN

1. f0= 1.3 GHz	: OPERATING FREQ.
2. Pp= 2 MW	: PEAK POWER
3. Ga= 35 db	: ANTENNA GAIN
4. A.B= 1.3 Deg.	: AZIMUTH BEAMWIDTH
5. ECmin= .2 ECmax= 45 Deg.	: RANGE OF ELEVATION COVERAGE
6. Wm= 5 RPM	: ANTENNA SCAN RATE
7. fp= 360 Hz	: P.R.F
8. T= 6 microsec.	: PULSE WIDTH
9. F= 8 db	: RECEIVER NOISE FIGURE
10. RCS= 10 dbsm	: AIRCRAFT'S RADAR CROSS SECTION
11. R= 100 Km	: RANGE OF THE AIRCRAFT
12. Su= 1 m/sec.	: CHAFF RMS VELOCITY SPREAD
13. SNout= 10 db	: CLUTTER-TARGET SIGNAL RATIO (S/N)out

OUTPUT

THE BEST IMPROVEMENT THE DELAY LINE CANCELER WILL PROVIDE IS:

Imax= 175 numeric OR 22.4304 db

N= 2190750 : DIPOLES IN RESOLUTION CELL

```
10    PRINT : PRINT TAB(30); " PROBLEM # 10"
20    PRINT TAB(30); " ---------"
30    GOSUB 100  : GOSUB 510
40    GOSUB 540  : GOSUB 790
50    PRINT : PRINT " DO YOU WANT TO TRY AGAIN FOR DIFFERENT OR THE SAME DATA Y/N?"
60    INPUT D$
70    IF LEFT$(D$,1)="Y" OR LEFT$(D$,1)="y"   THEN 30
80    END
90    '**********************************
100   '          INPUTS THE DATA
110   '**********************************
120   PRINT : PRINT " ENTER THE SWEEP RANGE F1,F2 OF THE HF RECEIVER IN MHz"
130   INPUT F1,F2 : PRINT : PRINT " 1. F1-F2=";F1"-"F2;"MHz"
140   PRINT : PRINT " ENTER THE TIME THAT THE RECEIVER SWEEPS THE ABOVE RANGE OF FREQ."
150   INPUT T : PRINT : PRINT " 2. T=";T;"times/sec."
160   PRINT : PRINT " ENTER THE FREQ. RESOLUTION DF IN KHz"
170   INPUT DF : PRINT : PRINT " 3. DF=";DF;"KHz"
180   PRINT : PRINT " ENTER THE RECEIVER NOISE FIGURE F IN db"
190   INPUT F : PRINT : PRINT " 4. F=";F;"db"
200   PRINT : PRINT " ENTER THE ANTENNA NOISE TEMPERATURE Ta IN KELVIN"
210   INPUT Ta : PRINT : PRINT " 5. Ta=";Ta;"KELVIN"
220   PRINT : PRINT " IS THE INPUT DATA CORRECT Y/N?"
230   INPUT A$
240   IF LEFT$(A$,1)="Y" OR LEFT$(A$,1)="y"   THEN 490
250   PRINT : PRINT " WHAT OF THE FOLLOWING DO YOU WANT TO CHANGE?"
260   PRINT : PRINT " 1. THE SWEEP RANGE?"
270   PRINT : PRINT " 2. THE TIME THE RECEIVER SWEEPS THE ABOVE RANGE?"
280   PRINT : PRINT " 3. THE FREQ. RESOLUTION?"
290   PRINT : PRINT " 4. THE RECEIVER'S NOISE FIGURE?"
300   PRINT : PRINT " 5. THE ANTENNA NOISE TEMPERATURE?"
310   INPUT C$
320   IF C$="1"   THEN PRINT : PRINT " ENTER THE SWEEP RANGE F1,F2 OF THE HF RECEIVER IN
 MHz"
330   IF C$="1"   THEN INPUT F1,F2 : PRINT : PRINT " 1. F1-F2=";F1"-"F2;"MHz" : GOTO 430
340   IF C$="2"   THEN PRINT : PRINT " ENTER THE TIME THAT THE RECEIVER SWEEPS THE ABOVE
```

```
RANGE OF FREQ."
350  IF C$="2"  THEN INPUT T : PRINT : PRINT " 2. T=";T;"times/sec." : GOTO 430
360  IF C$="3"  THEN PRINT : PRINT " ENTER THE FREQ. RESOLUTION DF IN KHz"
370  IF C$="3"  THEN INPUT DF : PRINT : PRINT " 3. DF=";DF;"KHz" : GOTO 430
380  IF C$="4"  THEN PRINT : PRINT " ENTER THE RECEIVER NOISE FIGURE F IN db"
390  IF C$="4"  THEN INPUT F : PRINT : PRINT " 4. F=";F;"db" : GOTO 430
400  IF C$="5"  THEN PRINT : PRINT " ENTER THE ANTENNA NOISE TEMPERATURE Ta IN KELVIN"
420  IF C$="5"  THEN INPUT Ta : PRINT : PRINT " 5. Ta=";Ta;"KELVIN" : GOTO 430
430  PRINT : PRINT " IS EVERYTHING O.K NOW?"
440  INPUT B$
450  IF LEFT$(B$,1)="Y" OR LEFT$(B$,1)="y"  THEN GOTO 490
460  PRINT : PRINT " WHAT DO YOU WANT TO CHANGE AGAIN?"
470  PRINT : PRINT " HIT ANY KEY IN YOUR KEYBOARD AND EVERYTHING WILL WORK FOR YOU
MALAKA"
480  INPUT F$  : GOTO 260
490  RETURN
500 '*********************************
510 '       PRINTS THE INPUT DATA
520 '*********************************
530  LPRINT : LPRINT TAB(30); " PROBLEM #10"
540  LPRINT TAB(30); " ----------"
550  LPRINT : LPRINT " G I V E N"
560  LPRINT " ---------"
570  LPRINT : LPRINT " 1. F1-F2=";F1"-"F2;"MHz" TAB(20); " : SWEEP RANGE OF THE HF
RECEIVER"
580  LPRINT : LPRINT " 2. T=";T;"times/sec." TAB(20); " : TIME THAT THE RECEIVER SWEEPS THE
ABOVE RANGE OF FREQ."
590  LPRINT : LPRINT " 3. DF=";DF;"KHz" TAB(20); " : FREQ. RESOLUTION"
600  LPRINT : LPRINT " 4. F=";F;"db" TAB(20); " :RECEIVER NOISE FIGURE"
610  LPRINT : LPRINT " 5. Ta=";Ta;"KELVIN" TAB(20);" : ANTENNA NOISE TEMPERATURE"
620  RETURN
630 '*****************************************
640 '  CALCULATION & PRINTOUT FOR PART a:
650 '*****************************************
660  LET W1=(F2-F1)/(1/T)
```

```
670  LET T1=1/(DF*10^3)
680  LET W=W1*T1*1000      'KHz
690  PRINT : PRINT : PRINT " PART a:"
700  PRINT "-------:
710  LPRINT : LPRINT : LPRINT " PART a:"
720  LPRINT "-------"
730  PRINT : PRINT " W=";W;"KHz"; " : BANDWIDTH OF THE RECEIVER'S FILTER"
740  LPRINT : LPRINT "W=";W;"KHz"; " : BANDWIDTH FOR RECEIVER'S FILTER"
750  PRINT : PRINT " T=";T1;"sec."; " : TIME DELAY FOR RECEIVER'S FILTER"
760  LPRINT : LPRINT " T=";T1;"sec."; " : TIME DELAY FOR RECEIVER'S FILTER"
770  RETURN
780 '****************************************
790  '  CALCULATION & PRINTOUT FOR PART b:
800 '****************************************
810  LET T0=Ta  : F1=F/10 : F2=10^F1
820  LET Te=(F2-1)*T0 : K=1.38*10^-23
830  LET MDS=K*(Ta+Te)*(1/(2*T1))
840  LET MDS=CINT(10*.4342945**LOG(MDS))
850  LET MDS=MDS+F+30
860  PRINT : PRINT : PRINT " PART b:"
870  PRINT "-------:
880  LPRINT : LPRINT : LPRINT " PART b:"
890  LPRINT "-------"
900  PRINT : PRINT " M.D.S=";MDS;"dbm"
910  LPRINT : LPRINT "M.D.S=";MDS;"dbm"
920  RETURN
```

PROBLEM # 10

GIVEN

1. F1-F2= 2 - 32 MHz	: SWEEP RANGE OF THE HF RECEIVER
2. T= 25 times/sec.	: TIME THAT THE RECEIVER SWEEPS THE ABOVE RANGE OF FREQ.
3. DF= 2 KHz	: FREQ. RESOLUTION
4. F= 3 db	: RECEIVER NOISE FIGURE
5. Ta= 290 KELVIN	: ANTENNA NOISE TEMPERATURE

PART a:

W= 375 KHz: BANDWIDTH OF THE RECEIVER'S FILTER

T= .0005 sec.: TIME DELAY FOR RECEIVER'S FILTER

PART b:

M.D.S=-138dbm

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